西北农林科技大学
NORTHWEST A&F UNIVERSITY

陕西省本科高校实验教学示范中心

申报支撑材料

经济管理实验教学中心

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西北农林科技大学本科教学改革与发展行动计划

校教发〔2002〕289号

21世纪之初，我国高等教育发生了深刻的变化。教育规模持续扩大，教育体制改革稳步推进。WTO的加入和西部大开发战略的实施，给高等教育带来了新的机遇与挑战。人才培养质量，特别是作为高等教育主体的本科教学质量，已经成为当前高等教育改革发展的重点和关键所在。加强本科教学工作，成为高等教育的主体和基础工作，提高教育教学质量，也成为各级政府和全社会共同关注的问题，成为高校自身改革与发展的历史使命。

我校有着重视教学质量的优良传统。学校组建三年来，教学工作与体制改革同步推进，取得了突出的成效，为进一步深化改革奠定了良好的基础。专业规模稳步增加，多学科综合化的专业格局初步形成。本科专业数从组建初的31个增加到49个，并增设了3个目录外专业；先后建立了40多个产学研实践教学基地；整合修订了本科专业人才培养计划和教学大纲，构建起了产学研结合为特色的人才培养新模式，并取得一大批教学改革成果。教学管理工作克服了体制改革过程中教学资源不足的困难，率先建立了校院两级管理体制，出台教学管理制度，有力的保障了教学运行秩序；启动实施了教学督导制度和学生评教制度，构建起了教学全过程质量监控体系。在教学条件与保障方面，教学基本投入逐年提高，学校基础设施建设和改造成效显著，为教学工作创造了良好条件；实验室改造、多媒体及教学网络建设极大地加快了教学现代化进程；校内分配制度的改革和学生管理工作的深化，有效地调动了教学双方的积极性。一个孕育着高质量人才培养的机制，高起点的教学环境，正在逐步呈现出来。

面对高等教育新的形势和要求，我校教学工作中存在的问题更显得十分突出和尖锐，这些问题概括起来主要集中表现在以下几个方面：

1. 教学工作是学校的中心工作，教学质量是学校生命线的认识，还没有充分深入到各级管理干部和广大师生的思想中，对教学工作中出现的问题相互推诿扯皮的现象仍然存在。

2. 校院两级管理的职责还不够清晰，两级教学管理和教学质量监控机制仍需完善，教学管理科学化和教学手段现代化需要加快推进。

3. 教学双方的积极性尚未充分调动起来。一些教师中仍存在"重学时轻质

量"、"只重教书不重育人"的现象，学风、教风建设的任务还非常艰巨，学院自主管理的职责和权利还没有落到实处。

4．课程教学质量没有形成稳步提高的态势。外语、高数等公共基础课程教学质量与兄弟院校相比，仍有一定的差距。

5．专业建设、课程建设没有完全落实，课程体系缺乏创新性，教学内容相对陈旧，教学方式比较单一，没有形成因材施教的多样化教学模式。

6．随着教学硬件基础的不断改善和教学投入的不断增加，相应的管理措施没有完全到位，缺乏有效的监控手段。

要从根本上解决现阶段我校本科教学中存在的问题，就要重新认识教学工作在学校中的地位和作用，理顺教学工作的各种关系，改变教学质量和教学管理工作仅靠教务部门的传统认识，树立全面教育教学质量观，各职能部门齐抓共管、相互协作、上下呼应、系统运行，把我校教学质量提高到新的更高的水平。

为了认真贯彻教育部4号文件精神，根据教学质量年工作要点，经过广泛的调研和论证，学校制定了这项《本科教学改革与发展行动计划》，并配套出台了23个教学管理文件。其主要目标是，经过各部门的协作奋斗，通过深化改革，建设具有时代特征和我校特色的产学研结合的人才培养新模式，及与此相适应的专业课程体系和教学管理制度，推出一批在全国有一定影响的农林高校特色教材和教学成果，培养和造就大批基础扎实、素质高、适应面宽、富有创新、创业精神和实践技能的优秀人才。"行动计划"主要内容如下：

一、教学管理制度创新行动

1．完善校院两级教学管理模式。按照学校校院两级管理体制的要求，明确校院两级管理的责任，尽快实现两级管理的制度化。各学院要充分发挥应有的自主办学、自我管理的权利，完善教学"三干"制度，定期召开教学管理工作例会，把教学管理工作真正落到实处。校教学督导组和各学院教学指导委员会要充分发挥指导作用，为教学工作出谋划策。

2．全面启动学院教学状态评价工作。通过学院教学评价，准确获得教学第一线的反馈信息；同时要以学院教学工作状态评价指标体系为规范，实施有效的教学过程质量管理和宏观调控，促进各级教学及教学管理工作逐步实现规范化和科学化，进一步提高学校及学院教学管理水平。

3．加快教学管理局域网建设，充分发挥现代信息技术为教学服务的功能，

力争在年内实现教学管理工作网络化，使学生能在网上选课，查询成绩，了解有关教学工作信息。

4．进一步完善学分制，在不降低学业要求的前提下，进一步完善"主辅修制"、"第二专业学士学位制度"。按照校院两级管理体制的要求改革考试制度，修订"学士学位授予实施细则"等管理文件。进一步增强学制的弹性，鼓励学生提前读研和毕业，全面调动学生学习的积极性。

5．建立领导干部听课制度。要求处级以上干部必须深入课堂听课。组织部会同教务处每学期初公布各处级干部听课安排，落实措施，保证每学期人均听课不低于8学时。

6．完善学生评教制度。引入激励机制，将学生评教结果同职称晋升和学校奖惩制度挂钩。评价结果不合格的教师，要责成其写出自查总结及自我改进方案，并由教研组落实帮教措施；评教连续两年不合格的教师，暂停其教学工作，直至改进合格后，方可讲授本科课程。

二、教学基本建设与保障行动

1．完善教学经费投入与管理制度。从今年起，每年划拨的教学经常性经费（教学管理，教学业务、教学差旅等）不低于学费收入的30%。根据我校实际情况和教学改革重点，设立教学改革与建设专项经费，主要用于名牌专业建设、重点课程建设、教材建设、多媒体及网络建设、数学建模、外语教学改革等专项经费。教学经费使用必须实行"按项核算、专款专用"的原则，保证教学经费足额有效的使用到教学工作中。各学院及教学工作人员要严格遵守国家财务制度，对弄虚作假、截留、挪用、挤占教学经费等违反财务管理规定的行为，要严加处理。

2．加强多媒体教学建设与管理。学校制定"多媒体教材建设规划和管理办法"，加强多媒体教材建设，建立奖惩机制，调动教师制作多媒体课件的积极性和主动性，充分发挥现有教学资源和现代化教学手段的作用，力争在2-3年内使我校多媒体教学课程占所开课程的30%以上，其中骨干课程占到50%。多媒体教室要由现在的8个增加到40个，基本保证教师对多媒体教学需要。大力开展中青年教师的现代化教育技术理论和技能培训，推进多媒体教学手段的普及和多媒体教学水平的不断提高。

加强多媒体教室管理工作。提高多媒体教室的利用率，多媒体教室分校院两级管理。学校多媒体教室由网络与教育技术中心统一管理，教务处调配使用；各

学院自建的多媒体教室由本学院管理使用，任何单位不能用多媒体教室开设网吧或进行创收经营。

3．加强实验室建设与管理。依据"西北农林科技大学关于加强实验室建设的实施意见"，制定"实验室工作条例"。要尽快理顺实验室管理体制，明确学校和学院两级管理的职责，明确实验室主任及实验室技术人员的职责。使实验室建设与管理逐步规范化、制度化。

强化实验教学队伍建设。提倡知名教授担任实验室主任，鼓励硕士、博士研究生以助手的身份参与本科实验教学。要对现有实验技术人员进行再培训，提高其业务水平和工作能力，选留和引进高学历、高层次人才，充实到实验室教学工作中。

加大基本建设投入，改善实验室用房。按照学校的发展规划，加大实验室基本建设与投入力度，改善和增加实验室用房，力争使我校教学实验室用房总面积达到60000㎡以上，达到教育部和陕西省教育厅对实验室的优秀评估和合格评价要求。进一步加大设备投入，提高装备水平，每年从学校经费中重点安排实验室建设费，逐年增加实验设备费、实验维修费及实验室改造费用。

4．完善教学后勤保障制度。在学校教学用房和教学设备等方面，摸清家底，合理配置和充分利用现有资源，明确管理责任，使现有教学资源得到最大限度的利用，直接面对师生，做好教学后勤保障。后勤管理部门要做好教室、实验室用房的调配和日常管理工作，定期对教室和实验室的水、电、暖进行检查，发现问题及时解决，确保学校教学工作正常进行，为广大教师和学生创造一个良好的教学环境。

5．要重视和加大校内外实践教学基地的建设，保证实践教学环节顺利进行。要按照《西北农林科技大学校外教学实践基地管理办法》和《西北农林科技大学校内教学实习基地管理办法》，加强校内外实践教学基地的管理与建设，保证每个教学实践环节的顺利进行。各学院（系）、教务处加大校外实践教学基地的建设力度，采取技术服务等多种形式实现学研产紧密结合，建设一批高质量、高水平的产学研合作教学基地，培养学生的创新精神和动手能力。

建立健全各项管理制度和服务体系，增加能体现学科发展前沿和时代特色的图书资料，开通网络检索系统，保证图书馆开放时间，提供优良的查阅资料和学习环境。网络信息要畅通，校园网络内容要及时更新，利用网络窗口加大对学校

的宣传力度。同时要加快网络教学平台建设，大力开展远程教育。

三、教风建设与师资队伍建设行动

1．加强教风建设，规范教学岗位职责。学校教师的师德和教风，不仅直接关系到教学质量的提高，也对学生的世界观、价值观、人生观的形成有直接影响。教师应具有高尚的师德、优良的教风和敬业精神，具有严谨的科学态度和高度的责任心，要把主要精力投入到人才培养和教学工作中。《西北农林科技大学教师教学工作规范》，明确了教师在各个教学环节中的职责，为实现教学工作的规范化提供了制度保障。要以此为标准，强化教学过程管理，促进教风建设，认真执行《西北农林科技大学教学事故处理暂行规定》，依法治教，按制度办事，对出现的教学事故要严肃处理。

2．坚持教授上讲台制度。我校现有在职的教授、副教授都要上讲台，讲授本科课程。教授每年为本科生至少讲授一门课程。无特殊原因，连续两年不服从学校安排讲授本科课程的，不再聘任教授或副教授。对不讲本科课程或达不到本科教学工作量要求的教师，不能被聘任为教授或副教授，对于教学质量差，学生反映问题较多的教师学校根据有关规定暂停或取消其授课资格，并予以调离教师岗位。在教师职务聘任中，要实行教学考核一票否决制，没有完成规定的本科教学工作量或教学效果差的教师不能聘任高一级职称。

3．加强中青年教师队伍建设。提高本科教学质量，必须把中青年教师队伍的建设放在重要地位。依据《西北农林科技大学青年教师培训工作条例》，有计划、有目的地培养中青年教师，特别是承担基础课和公共基础课的中青年教师。新上岗的青年教师必须参加岗前培训；青年教师独立授课前要至少做两轮的教学辅助工作；要进一步完善青年教师导师制，加强青年教师教育理论、现代教育技术运用能力的培训与提高。力争在5年内，使45岁以下的教师普遍掌握现代教育技术手段。

4.完善教学奖惩制度，充分调动教师的教学积极性和主动性。制定出台我校《主讲教师教学工作奖励办法》，每年拿出50万元作为教学奖励津贴，对在教育教学、工作量、学生评教结果、教育教学研究与成果、校教学督导的反馈意见等方面进行综合评价。

四、学风建设与学生管理制度改革行动

学生是学校教学活动的主体。优良的学风对学生起着潜移默化的教育作用，

使保证教育质量的重要前提。要把学风建设作为今后一个阶段学生教育管理工作的一项内容。

1. 学风建设要激励学生个性发展，积极培养学生勤奋自律、刻苦钻研的学习态度和敢于拼搏、勇于创新的价值取向，营造勤奋、求实、开拓、创新的优良学风。要围绕素质教育积极开展丰富多彩的文化活动，努力营造自由、民主、平等、互助的教学氛围，充分调动学生在教学中的主动性、积极性和创造性，使学生从被动接受的教学客体转变为主动参与的教学主体。把学生的思想政治教育贯穿到工作以提高人才质量为目标的专业教育、素质教育当中。建立大学生心理咨询服务中心，开展心理咨询，促进大学生健康成长。

2. 建立健全学生管理规章制度，促进学风建设。要建立科学的学风建设管理体系。学校要成立由党政领导，学生处、教务处、人事处、团委等部门及学院（系）领导组成的学风建设管理机构，制定有关学风建设的具体措施。要从规章制度建设入手，加强学风建设，规范学生行为。

3. 建立竞争激励机制，促进学风建设。要做好学生"三级考评"工作，通过建立和完善学生素质综合测评，学生班级工作评估及学院学生教育管理工作考评制度，在学生之间、班级之间、学院之间引入激励机制，使学生教育管理工作和学生素质培养逐步由过程管理到过程与目标管理相结合，充分调动学生、班级及学院的积极性和创造性，促进学风和校风建设。

4. 抓好招生与就业指导工作。以提高生源质量和第一志愿率为重点，摸索建立稳定生源基地的途径，提高生源质量。大力开拓就业市场，把就业推荐作为常年性工作，主动走出去，运用各种渠道和手段，积极推荐学生，保证本科毕业生一次就业率逐年达到90%以上，体现出我校的学生培养质量。要组织保证，要按照提高素质，优化结构，相对稳定的要求，建设一支政治强、业务精、作风正、以专职为骨干、专兼职相结合的学生政工干部队伍。学院（系）要在党政干部和教师中选拔一批思想政治水平高，作认真负责，在学生中享有一定威信的干部和教师兼职辅导员或学生班主任。兼职辅导员和班主任在学院领导下，协助辅导员一起做好学生思想教育和日常管理工作。不断完善学生党员、学生干部担任助理班主任制度，提高学生自我管理、自我教育、自我服务的能力。加强学生政工干部的管理和考核，注重学生政工干部的培养，提高其业务水平和管理经验。

5. 坚持校领导接待学生制度。学校领导坚持每两周接待学生一次，听取学生

的意见。学院（系）领导也要定期与学生座谈，了解学生思想动态和学习情况。

五、专业与课程建设行动

专业建设与课程建设是学校教学基本建设的重点和关键。学校今后将采取专项建设的方式，加大投入，扎实有效地做好教学建设工作。

1．以名牌专业建设为重点，通过专业改造带动专业建设，优化专业结构。名牌专业建设应体现学校本科教学和人才培养的要求，反映现阶段高等教育教学改革的基本趋势与发展方向，突出专业特色，能对人才培养、教学改革与建设起到示范作用。根据我校实际，名牌专业建设工作要贯彻"全面规划，分批建设"的原则，建设一批，验收一批。学校每年划拨50万元专项经费，重点建设3—5个专业。力争在5年内，建设20个左右校级名牌专业，10个左右的省级名牌专业。

2．加强专业骨干课程建设，保证专业培养质量。骨干课程建设要体现专业培养目标，突出办学特色，遵循"保证重点、分批建设、全面推进"的原则，按学院分专业逐步进行。学校将每年拿出50万元作为经费投入，计划经过5年建设，使我校各专业的骨干课程达到10门左右，并以此带动相关课程建设。骨干课程讲授要设主讲教授岗位，实行主讲教授竞争上岗。

3．落实"加强外语教学工作实施意见"。改革方案要目标明确，责任到人，奖惩分明，教师、学生一起抓，学校、学院齐上手，力争使我校的外语四级通过率每年按15%递增。毕业时外语四级考试成绩不合格者，不授予学士学位。

外语教学质量要从教师的课堂教学抓起，制定外语课教学标准，建立教学研究制度、青年教师培养制度，下气力抓好青年教师的教风和教学能力，指导青年教师做好课堂教及时研究交流，不断改进教学方法，提高教学水平。

4．稳步推进我校骨干课程双语教学工作。按照"教育要面向现代化、面向世界、面向未来"的要求，为适应经济全球化和科技革命的挑战，本科教育要创造条件使用双语教学，力争三年时间使双语教学的课程占到各专业骨干课程的30%。对使用双语教学的课程，要在教材建设、教学手段和教师培训提高等方面重点支持，有计划地积极引进原版教材授课，暂不具备双语教学条件的骨干课程，可以采取先实行外语教材，中西语言结合的授课方式逐步到位。

5．加强公共基础课教学。公共基础课教学是培养学生创新能力、保证教育质量的重要基础。要把提高教师的授课质量放在首位，改革教学内容体系，使用优秀教材，改进教学方法和手段，提高课堂教学质量。要加快基础课教师队伍建

设，制定优惠政策吸引国内外优秀人才来我校任教，缓解任课教师不足的矛盾，提高现有教师待遇，争取2-3年改变我校基础课特别是高等数学、化学、生物学等课程教学相对滞后的局面。

6．加大教学研究与改革的步伐，学校每年拿出20万设立教学研究与改革专项基金，用于资助重大的教学改革研究项目，推动学校教育教学改革研究的进程，培育优秀教学成果。教师及教学管理人员要积极进行教学研究和教学改革。教育教学研究论文要作为年度评优和津贴发放的范围，省级及以上教学成果奖纳入奖励津贴之中，按级别分别给予奖励。

高等学校的根本任务是培养人才，教学工作是学校的中心工作，本科教育是高等教育的主体和基础，人才培养质量是高等学校的生命线。学校各部门要更新思想观念，处理好改革与发展、教学与科研、规模与质量的关系，牢固树立全面教育教学质量观，及时研究解决本科教学工作中的新情况、新问题，不断推进观念创新、制度创新和工作创新，齐抓共管，把本科教育质量提高到一个新水平！

西北农林科技大学教室及教学实验室后勤保障管理办法

校教发〔2002〕289号

为了加强对后勤资源的管理，使现有资源得到最大限度的利用，确保学校教学工作正常进行，为广大教师、学生创造良好的教学、学习环境，特制定本办法。

一、教室管理

1.教室按管理和使用划分为专用教室和公用教室。专用教室是指划分到各学院（班级）单独使用的教室，公用教室是指由学校职能部门统一调配，各学院共同使用或交叉使用的教室。教室实行集中管理、统一调配、分工负责的制度。其日常管护、家具配置由后勤管理处负责，使用、调配由教务处负责。

2.根据实际需要，每栋教学楼设一定数量的教师休息室，后勤管理处负责配备沙发、电话、热水器等设施，并负责日常管理。

3.教学楼设专职管理员一名，并配办公室一间。管理员具体负责本栋教学楼的日常管理工作，按时开关教室和教师休息室，随时检查各个教室水、电、暖、家具使用情况，并负责日常检修工作，负责监督检查清洁工作。

4.公共教室粉笔由设备处负责采购，供应到各教学楼管理员办公室（值班室），由管理员具体负责各个教室的配送。粉笔、板刷配置应充分考虑教学的实际需求及广大教师、学生健康需要，颜色搭配合理。专用教室的粉笔、板刷由相关管理学院安排学生代表就近到教学楼管理员办公室（值班室）按需领取。

5.学校各类教室家具配置、调整计划由教务处根据实际需要提出，后勤管理处负责落实。每年寒、暑假前教务处应将下学期教学家具配置、调整计划报送后勤管理处。

6.广大教师、学生要爱惜学校资产，不乱画、乱刻、乱涂，应珍惜每一根粉笔、每一个板刷，自觉做好教室资产的维护工作。离开教室时主动熄灯和关闭电扇等设备。

7.后勤管理处应定期对教室进行检查，发现问题及时解决，确保公用教室电源插座、照明灯具、电扇等设施正常使用率在95%以上，确保教学楼内厕所整洁，无臭气，无结垢。专用教室由使用单位负责检查维修。

8.严格按照学校作息时间安排好实验室水电暖供应时间，确保供应正常。教室水电暖供应按照学校作息时间标准，上课提前1个小时供应，下课后推迟1个小

时停止。遇到阴雨下雪根据实际情况提前供应。

9.教室每天开放时间不少于14小时。根据学生学习的实际需要，按校区设立通宵供电教室若干，保证学生学习需要。寒暑假期间根据实际可以开放个别公用教室。

二、实验室管理

1.学校各类实验室由教务处委托各学院（部门）管理，其室内卫生、水电暖维修等由相关学院（部门）负责管理，实验台、仪器柜等家具由后勤管理处负责配置。

2.实验室家具日常管理由后勤管理处委托相关学院（部门）管理，后勤管理处负责监督、检查。各学院（部门）应确保实验室家具的正常、安全使用，凡因管理不善造成的损失，学院（部门）自行负责更新。

3.按照实际需要学院（部门）应设专职实验室管理员。管理员具体负责本实验室的日常管理工作，随时检查实验室水、电、暖、家具使用情况，并负责日常检修工作。

4.学校各类实验室家具配置、更新计划由相关学院（部门）根据实际需要提出，教务处审核后，后勤管理处负责落实。每年寒、暑假前各学院（部门）完成实验室家具配置、调整计划，经教务处审核后报后勤管理处

5.后勤管理处应定期对实验室进行检查，及时督促维修，确保实验室电源插座、照明灯具、电扇等设施正常使用率在95%以上，确保实验安全。

三、其他管理

1.各类学生食堂应严格按照《食品卫生法》及上级行业主管单位的要求，认真落实餐饮安全工作各项措施，注重营养，适应学生多口味需求，努力降低服务成本，提高饭菜质量。学生食堂一日三餐，按时供应。

2.按学生集中住宿地域的不同，在每一个相对集中的学生区设立全天供应餐厅，确保学生就餐方便、快捷。

3.改造学生宿舍供电设施，实行24小时供电。每月按人按宿舍给予一定数量的免费用电指标，节余留用，超额用电由学生自行购买。

四、本办法由后勤管理处负责解释。

五、本办法自发布之日起施行。

<div style="text-align:right">二〇〇二年九月三十日</div>

西北农林科技大学关于加强实验室建设的实施意见

校教发〔2002〕289号

实验室是衡量高等学校教学水平和科研能力的重要标志。高水平的实验室建设是提高教学质量、出高水平科研成果的前提，是学校事业发展的基础。

我校合并为实验室建设和发展创造了良好的条件。然而，目前我校实验室摊摊多、规模小、底子薄，先天不足。实验室发展处在一个条件和困难同在，机遇和挑战并存的关键时期。因此，进一步提高认识，加大实验室建设力度，改善和提高实验室的设施环境与装备水平；建立一支结构合理、人员稳定的高素质实验技术队伍；理顺实验室管理体制，优化资源配置，建立一个结构合理、功能优化、协调发展的实验室体系；加强实验室管理，建立有利于提高实验室综合效益的运行机制和管理制度，建立有利于调动实验人员积极性的有效措施和实验室仪器设备等投资评估的有效机制是实验室工作的当务之急。为此，提出以下加强实验室建设的实施意见。

一、健全管理体制和制度，实施科学管理

1. 制订工作条例，健全管理机构，明确各级职责

根据教育部《高等学校实验室工作规程》、《高等学校基础课实验室评估标准》等文件要求，制订我校实验室工作条例，从实验室的基本任务、管理体制与机构、实验室建设、工作人员及职责、实验室技术安全等方面做出规定。理顺实验室管理体制，明确学校和学院两级管理的职责，明确实验室主任及实验技术人员的工作职责，使实验室建设与管理逐步规范。

2. 成立实验室工作委员会，加强实验室建设与管理的监督指导

为加强实验室建设与管理，成立学校实验室工作委员会。实验室工作委员会在主管校长领导下，审议学校实验室发展规划；参与学校实验室机构设立、调整、合并、撤销的研究与论证；参与实验室工作的检查、评估及评价等工作。实验室工作委员会的设立，将会更好地贯彻落实《高等学校实验室工作规程》，促进我校实验室的改革、建设与管理。

3. 建立配套的管理制度，实施有效的管理

制定和完善实验室仪器设备管理、低值易耗品管理、档案与基本信息管理、技术安全与环境保护等方面的规章制度及管理办法；要建立健全实验室管理与建

设中的文件资料档案；定期开展实验室工作评估和考核评奖活动；推行实验室计算机、网络管理，使实验室管理实现标准化、规范化和科学化。

4. 探索新的管理模式，提高实验室效益

积极推行重点科研实验室"资产封闭式管理，人员与项目开放流动式运行"的管理运行机制，提高资产与设备的使用效益。教学实验室要建立符合实验教学自身特点的管理运行机制，充分发挥实验室的功能。

二、优化资源配置，分步实施，完成我校实验室的整合与改革

学校组建后自然形成了117个教学实验室，重复、交叉问题突出，协调不够，管理不规范。因此，必须首先理顺和规范，才能进行有效的管理与建设。

1. 基本实施原则

（1）立足实际，着眼未来，协调发展的原则。要处理好改革、建设、发展之间的关系，顾全大局，群体优化。既要扎实、稳妥，又要有大目标、大步伐。要确实做到有利于理顺管理体制，增强整体实力和充分发挥实验室的综合效益；有利于加强学科建设，推进科学研究和提高总体办学水平；有利于提高学校在西部建设和二十一世纪教育、经济、科技及社会发展中的适应能力，促进我校持续发展。

（2）加强基础，扩大规模，保证教学的原则。加强基础设施和基础实验室的建设，特别是公共基础实验室和跨学科、跨专业的专业基础实验室，要扩大规模，增强活力，进一步拓宽其专业适应面，增强其专业应变和适时承担教学、科研实验任务的能力。

（3）突出重点，扶持新兴，发挥优势的原则。以国家级、部省级和校级重点实验室建设为核心，对能体现我校特色和优势的新增专业实验室制定相应的倾斜政策，使我校重点、特色、优势学科和新兴学科的实验室始终处于优先发展的地位。为培养高层次、高质量的人才和多出、快出重大科技成果提供强有力的实验支撑。

（4）统筹规划，合理设置，提高效益的原则。根据学校建设的总目标，合理设置实验室结构体系，打破条块分割，教学、科研紧密结合，实行开放性、协作性运作模式，促进资源共享，使其充分发挥效益。

2. 实施步骤

对我校现有实验室按照学科结构和功能，进行重新规范和调整，整体规划，统一设置，建立一个结构合理、功能优化、协调发展的大学实验室体系。按教学、

科研两大类，分步理顺和规范。

第一步，在2002年9月前完成教学实验室的归并整合。对全校目前的117个教学实验室，按照实验室的性质、功能和承担的任务，归并整合。构架起一个合理的教学实验室体系雏形。教学实验室按照校管实验室、院管中心（综合）实验室、院管专业实验室三种类型进行设置和管理：即全校公共课和跨学院、多学科的基础课教学，设校管实验室，暂依托有关学院代管；学科及专业相近，设院管中心（综合）实验室；学科及专业差异较大，互不兼容，设院管专业实验室。

第二步，在2002年12月前理顺科研实验室的设置。对全校的科研实验室进行全面整顿，去除一些没有必要的设置和多年过时的空架子、空牌子。对于一些有特色、有发展潜力、有优势、有重大科技成果的学科，进行重点扶持，加强其实验室的建设，使我校科研实验室能形成一个优良的体系，具备支撑重点学科和重点研究项目的综合实力。

第三步，随着学校的建设和发展，将公共课、涉及面广的基础课或专业基础课实验室，建立由学校统一管理的基础课教学实验中心。并争取创建国家级基础课教学实验示范中心。科研方面，要大力加强重点实验室的建设，除继续加强已有的黄土高原土壤侵蚀与旱地农业国家重点实验室的建设外，争取在西部旱区农业（作物育种）、家畜生殖内分泌及胚胎工程、农业水土工程等方向上新建1-3个国家级重点实验室；除继续加强已有的13个部省级重点开放实验室的建设外，争取在园艺植物资源及种质改良、作物营养、木材科学、草原科学、食物安全技术检测、设施农业工程及旱作农业机械工程等方面新建2-7个部省级重点开放实验室。

到2005年末，我校公共基础及专业基础实验室应能保证16000名本科生、2500名研究生的教学和一些基础性科学研究的需要，实验室达标率达到100%；重点实验室应具有支持重点学科和重点研究项目的实力，在同一领域达到国内先进水平；一般专业实验室应具有本专业的特色和优势，能够完成本专业的教学、科研实验任务，为本专业教师及科研人员提供相应的研究条件和场所，达标率达到90%以上；全校教学实验开出率达到95%以上，实验室综合实力和整体教学、科研水平达到国内先进水平。

三、加强基本建设，提高装备水平

1. 加大基本建设投资，改善实验用房

按照学校的发展规划，今后5-10年，我校将形成以本科生教育为主体，以研究生教育为重点，积极发展成人教育的多学科、多规格、多层次的办学格局，本科生将达到18000-20000人，研究生将达到3000-4500人，成人教育学生将达到20000人以上。按照这个规模，我校现有的35000㎡教学实验用房，远远不能满足要求，一是面积不足，二是质量不高，室内基础设施和基本条件装备较差，离我校总体办学目标具有相当大的差距。为此，学校要抓住目前的发展机遇，下大力气，加大基本建设投资，改善和增加教学实验用房，力争使我校教学实验用房总面积达到60000㎡以上，使实验室在房屋使用面积和设施环境上，都能达到国家及各级评估、评价的要求和标准。

2．加大设备投入，提高装备水平

目前，我校教学设备配套数量不足，陈旧、老化、落后及超期服役的现象十分严重。现有教学设备中，80年代及其以前购置的、90年代购置的、90年代以后购置的大约各占1/3，许多仪器已进入维修高峰期，即将报废，难以保证新时期教学、科研的需要。这些情况迫切需要我们在今后的几年中，大量进行补充、配套和更新。

学校除在基本建设启动费中重点安排实验室建设项目外，还要发挥教育事业费、科研项目费和基本建设费的主渠道作用。要逐年增加实验维持费、设备费、维修费和实验室改建费等实验室投入的生均经费比例。要从基建设备费中每年提出一定比例用于常规教学仪器设备的更新，积极争取国家资助性建设项目经费及专项设备费。鼓励、支持、引导各种科研项目经费用于实验室建设和购置仪器设备。发挥已有装备、设施和技术优势，积极开展实验技术服务和科技联合、协作，争取横向经费，扩大自身建设。同时，要大力开展修旧利废、自制改装、挖潜改造、开源节流等活动，以弥补经费的不足。

在多渠道筹资的基础上，要下大力气，努力完成我校实验室在基本设施、基本条件方面的建设，要加强实验室在修缮、改建和水电安装方面的基础工程，加强配套设施、工作条件和环境氛围的建设，全面提高其装备水平。"十五"期间要完成2亿元的设备投入，主要解决基础教学、计算机教学、外语教学、多媒体教学、重点学科、重点项目等方面的设备问题，力争使我校常规教学设备总更新率每年保持在15%以上，完好率达到80%，配套率、利用率均达到90%，使实验室真正成为科学研究的支柱和现代化的育人基地。

四、努力建设一支高素质的实验技术队伍

实验技术队伍的建设，对实验室的建设和发展以及实验室功能的发挥利用，起着至关重要的作用。我们要努力建设好一支规模适度，素质优良，结构合理，相对稳定的实验技术队伍。为此，我们必须提高对实验技术队伍建设重要性的认识，通过加强人员配备、岗位培训、业绩考核等方面的工作，全面提高实验技术队伍的整体素质。有计划、有针对性地举办各种岗位培训，促使实验技术人员及时更新知识，不断提高业务水平。落实岗位责任制，搞好年度及任期考核，把完成任务的数量、质量、效益及贡献与评优、晋级、聘任和奖惩结合起来，充分调动实验技术人员的积极性和创造性。同时，要加强思想政治工作，加强职业道德教育，改进工作作风，努力建设好一支思想作风优良和业务素质过硬的高质量的实验技术队伍。

五、本实施意见由设备处负责解释。

六、本实施意见自发布之日起实行。

二〇〇二年九月三十日

西北农林科技大学实验室技术安全与环境保护工作细则

校设发〔2003〕149号

一、为了加强实验室技术安全及环境保护(以下简称技安环保)工作的管理,防止职业危害、技术危害、环境污染及其它公害的发生,保障师生员工人身安全及国家财产安全,保护校园学习、生活环境,保证教学、科研工作的正常进行,特制定本工作细则。

二、技安环保工作是关系到学校财产安全及师生身体健康的重大问题,各实验室及主管实验室的领导,应将此项工作列入本职工作范围,实行岗位责任制,做到安全操作,文明教学与科研。

三、技安环保工作实行"专管成线,群管成网,专群结合,重在预防"的原则,各实验室应设兼职环保技安员,适时组织技安训练,进行环保教育,充分发挥实验技术人员作用,形成技术安全网,确保各项工作的正常开展。

四、各实验室要针对技术安全及环境保护的要求,对参加实验的学生进行技安环保教育。对有可能产生公害或人身危害的实验项目,在学生实验或下厂站实习前,均要进行专题讲解及技术训练,达到"应知、应会",方可进行独立操作。

五、凡采用新技术、新工艺增添的新仪器、新设备,增开的新实验、新项目,制造的新产品或对旧产品进行新的技术改造时,都要进行试做、试制、试运行,各项技术指标均应符合技安环保要求。

六、实验人员属于新上岗或调换新的岗位时,必须进行技术训练和安全环保教育。禁止未成年人、临时工和不懂操作规程的人从事危险作业和有可能产生公害的工作。

七、对各种机械设备中的传动带、明齿轮、砂轮、电锯、接近于地面的连杆、转轴、飞轮、皮带轮及压力机械的施压部位,都要安装安全防护装置,定期检查,确保其处于良好的技术安全状态。

八、对各种电器设备的线路绝缘、保险设施、裸露密封、外壳接地、自动开关、安全保护、警示标牌等,都要按规定设置、安装和及时检修,并有专人检查管理,严禁违章带电使用。

九、对各种压力设备中的安全阀、压力表、水表、管道、气瓶等,要按规定储运、检测和安装,力求做到防火、防晒、防爆、防超越安全极限。

十、实验室所使用的易燃易爆品、毒害腐蚀品、自燃物品及氧化剂、过氧化物等, 要有专人保管领用制度。对于易燃、易爆等化学危险品有可能引起的损害, 应有消除和控制的措施。对于散发有害健康的烟雾、毒气、粉尘等, 应安装通风、吸尘、净化装置。在接触酸、碱等腐蚀性物质, 且有烧伤危险的工作地点, 要设有冲洗设备。

十一、实验室工作要谨防对环境和人体的危害。实验中所产生的废气、废水、废渣、烟雾、粉尘、噪声、辐射、振动、射线等技术污染物, 要有防护和安全处理措施。严防危险物品的渗漏、混合、溢流、腐蚀、丢失等现象的发生, 禁止不按规定, 对危险品和污染物进行随意装卸、运输、贮存、堆放、弃置、倾倒和排放。

十二、实验中提取或产生的各种流行病和传染病病源, 包括各种疫苗、菌种等, 要妥善、安全的保存和使用。有放射性物料及射线装置(包括伴有产生射线的电器产品)的实验室, 应按照上级主管部门颁发的放射性物品管理条例, 加强管理, 谨慎操作, 严防泄漏和污染。

十三、实验室在校园内采集植物及土壤标本, 应注意保护环境, 不得损害园林、绿地及自然景观。

十四、各实验室应树立"安全第一, 重在预防"的思想, 重点部位在节假日、易出问题的时间、季节, 要留人值班或定时检查, 要克服侥幸心理, 及时消除隐患。若有事故发生, 要及时上报, 及时处理, 作好记录, 确保师生员工的人身安全及校园环境不受危害。

十五、学校对一切不遵守纪律, 不负责任, 违反技安环保制度, 造成重大事故者, 将分不同情况, 追究责任, 给予严肃处理, 对于触犯法律的, 要追究法律责任。

二○○三年五月二十二日

西北农林科技大学实验室工作档案管理办法

校设发〔2003〕149号

实验室工作档案是实验室建设与发展的真实记载，是实验室工作的重要组成部分。为了进一步加强实验室的管理，使实验室工作逐步迈向科学化、规范化的轨道，提高办学水平及投资效益，为教学、科研服务，特制定本办法。

一、各级实验室及其主管部门要高度重视实验室工作档案的管理，必须有专人负责档案的收集、整理、汇编及存档工作。

二、实验室工作档案可分为文书档案和电子档案两种形式建立，文书档案以保存文件、资料的实物形式为基础，电子档案以保存文件、资料的电子形式为基础，实验室可根据实际工作需要及上级主管部门对实验室档案工作的要求，同时保存档案的两种形式或只保存其中某一种形式。

三、实验室文书档案收录的内容及范围包括：

1.实验室成立的申报、论证资料，批文及各种规章制度、办法、岗位职责等文件资料；

2.实验室发展建设规划、改革方案、实施计划、有重要价值的文件及资料；

3.实验承担任务资料(实验教学、科研、开发与社会服务等项目的有关资料)；

4.实验室工作人员情况(室主任、教师、实验技术人员及实验工人等)；

5.报送上级主管部门的各种统计报表；

6.实验室年度工作计划及总结报告；

7.实验室经费及使用情况资料；

8.实验室工作量统计报表及各种考核、评估、奖罚、晋升等统计资料；

9.实验教学授课计划表及实验教学进程表；

10.实验项目管理卡，实验教学大纲、实验教材、讲义、指导书及参考资料；

11.近五年实验教学考试题目、成绩册及有关分析、记录资料；

12.实验室改建情况、仪器设备修旧利废、自制改进等情况资料；

13. 实验室大型、精密、贵重仪器设备的使用、维修、保养记录；

14. 实验仪器设备等固定资产帐、卡及低值、耐用品帐目；

15. 实验室工作记录、工作日志、技安环保检查记录及承担的其它任务资料。

其中：学院及实验室编制、收录的内容为1-15条；学校职能部门编制、收录的内容为1-5条。

四、实验室电子档案收录的内容及范围包括：

1. 实验室基本情况数据资料；

2. 实验项目数据资料；

3. 实验室专职工作人员数据资料；

4. 实验项目电子卡；

5. 实验室仪器设备数据资料；

6. 实验室其它固定资产及其重要配套设施数据资料；

7. 实验室根据实际需要所形成的其它重要电子资料。

其中：第1、2、3条按教育部规定的数据传输内容及格式建立；第4条按学校主管部门的要求建立；第5、6条按学校国有资产管理部门的要求建立；所有各条均需每年更新，如期上报。

五、实验室工作档案必须具有真实性、规范性、完整性和连续性，从实验室建立之日起开始建立档案，逐年积累，严加管理。

六、档案管理人员要高度负责，及时收集，定期整理，如有缺陷，应及时补充。要严格档案借阅手续，按规定借出，按期收回。管理人员如有变动，应及时办理移交手续。

七、实验室主任及主管部门要切实加强对档案的管理及监督检查，需要上报的，需经实验室主任审核后，于当年12月30日前报实验室主管部门，由主管部门统一汇总上报。

八、涉及实验室工作档案的性质、保存期限、销毁等本办法未尽事宜，按《西北农林科技大学档案管理办法》有关条款执行。

九、本办法由设备处负责解释，从发布之日起执行。

二〇〇三年五月二十二日

实验室仪器设备管理制度

设发〔2003〕1号

一、实验室仪器设备要有专人负责领取和管理，建立帐卡，定期核查，每学期全面清对一次，始终做到帐、卡、物相符。

二、实验室仪器设备专管人员，对所管仪器设备负有全部责任，未经专管人员许可，任何人不得擅自使用、转移或调换。专管人员变动时，要办理好清理、移交手续。

三、现有仪器设备不得自行拆卸或改装。确需技术改装、改进，应经主管领导同意、校设备及资产管理部门批准后，方可进行。

四、实验人员要经常对所管仪器设备进行维护、保养和维修，确保完好可用。对于有特定技术要求的设备，要定期进行技术标定和校验，确保其精度和性能。仪器设备寿命周期已到，再无利用价值时，应及时报减、交回。

五、对于大型、精密、贵重仪器及设备，要逐台建立档案，专人管理，作好使用、维修记录。要提倡仪器设备的资源共享，互通有无，协作共用，充分发挥设备资源的作用。

六、实验室仪器设备属国有资产，对其进行使用、维修及管理，应认真贯彻执行国家及学校颁发的有关规章制度和管理办法，依法办事，确保其正常使用和运行。

二〇〇三年六月十一日

实验室低值易耗品管理办法

设发〔2003〕1号

一、实验室对低值、易耗品的使用和管理，要按照部门和单位隶属关系，统一领导，统一规划，分工负责，分级管理。

二、实验室要建立低值、易耗品帐目，进出有记录，手续齐全，帐物相符。要精打细算，定期核查，妥善使用，防止积压浪费。

三、对物品的计划、购置、管理、使用和回收，要建立严格的责任制，做到验收严肃认真，进出手续清楚，账目公开透明。

四、对于化学危险品的采购、储运、使用和管理，要严格执行国家《化学危险品安全管理条例》，有相应的安全措施及防护条件。

五、对于贵重、稀缺、易燃、易爆、剧毒、腐蚀、麻醉及放射性物品，要有专人专柜保管，精确计量，严格审批，防止一切事故发生。

六、对于报损、报废、调出校外的物品，要办理审批及有关帐务手续。对于残次、废旧物品及包装材料，应组织回收，物尽其用。

七、各实验室低值、易耗品专管人员发生变动时，必须有人接管，并认真办理交接手续，如有差错，必须及时查明原因处理。

八、学校对低值、易耗品实行年报制度，实验室应定期核查，按要求统计上报，接受有关职能部门的监督和检查。

二〇〇三年六月十一日

实验室仪器设备丢失损坏赔偿制度

设发〔2003〕1号

一、要贯彻勤俭办学方针，增强师生爱护公物的责任心与自觉性，尽量减少丢失损坏，确保设备器材完整、安全和有效使用。

二、凡由于不听指导、不按规程、工作失职、擅自拆改或不遵守规章等主观原因造成损失的，根据物质性质、事故情节及本人态度等，赔偿损坏价值的全部或一部分，赔偿数额按学校《仪器设备报减赔偿实施细则》执行。

三、凡由于设备陈旧、缺陷或因实验操作本身的特殊性，存在难于避免的客观原因，在正常使用中引起的损坏，从轻或免于赔偿。

四、实验室发生设备器材损坏、丢失事故，要及时报告，迅速查明原因，分清责任，及时处理。赔偿金额在800元以下的由实验室主任直接审核决定，800元以上的需经院所签署意见后，交由设备主管部门审批处理。

五、发生责任事故，当事人应主动写出书面检查。发生事故后隐瞒不报、推委责任、态度恶劣、损失重大的，从重处罚，并可根据情节进行处分，直至追究法律责任。

六、仪器设备损失赔偿费应由当事人一次交清，不得报销。所收缴的赔偿费应按规定入账并用于维修和补充设备器材等。

二〇〇三年六月十一日

实验室安全制度

设发〔2003〕1号

一、实验室对所有实验人员及学生要进行安全教育，牢固树立安全意识。根据本室设备、环境及实验特点，制定防火、防爆、防盗、防事故等方面安全管理措施，严格执行。

二、仪器室、重点要害部位及使用、存放易燃、易爆物品的场所要重点防护，安全措施到位，必要时设置安全监控预警系统。

三、室内水电设备和管线设施必须按要求装配，不准乱接乱拉，随意拆装、改线。各类在用设备应保持完好安全状态，有沟、坑、井、台、洞的地方，应设盖板、护栏或警示牌。

四、实验室必须配备符合规定的消防器材，放于显明、易用的位置，要有专人负责管理，定期检查，随时确保有效可用。

五、实验室钥匙要有专人管理，不得私自配备或转借他人。工作人员离开实验室前，必须关好门、窗、水、电、气等，保管好贵重物品。节假日前，要对实验室进行全面安全检查，假期有值班，假后复查，确保安全。

六、各实验室要定期进行安全检查。如发现不安全隐患，应及时排除，不能自行排除的，尽早报告有关部门处理。如发生事故，应及时采取措施，如实报告案情。凡隐情不报，造成重大损失的，将追究其应负责任。

二〇〇三年六月十一日

实验人员守则

设发〔2003〕1号

一、热爱教育事业，热爱本职工作，坚守工作岗位，遵守劳动纪律，爱护学生，专心施教，以身作则，为人师表。

二、刻苦钻研专业理论，不断提高实验技能，掌握本专业最新实验原理与方法，努力提高业务工作能力与实验技术水平。

三、熟练掌握实验室仪器原理与操作方法，做好维修、保养与管理工作，拟订有关操作规程及管理办法，提高科学管理水平。

四、管好财产帐卡，严格领借手续，认真做好各项工作记录，做好本实验室图书、设备及有关信息的收集整理与档案管理工作。

五、根据实验室主任和实验课教师要求，做好每次实验准备及辅助工作，搞好实验项目的更新与改进，保证实验顺利完成。

六、积极参加科学研究与实验技术的研究，主动承担科研任务，开发新的实验项目及内容，完成较高水平的实验报告或实验论文。

七、服从实验室主任领导，发扬团队精神，在分工负责的基础上，团结协作，顾全大局，努力做好本岗位工作，按期完成实验任务。

八、做好实验室日常管理，保持安全、清洁、卫生，保障人员安全和财产安全。

二〇〇三年六月十一日

学生实验守则

设发〔2003〕1号

一、实验前必须预习实验教材，明确实验原理、目的、要求、方法、步骤，熟悉所用仪器设备的性能及操作规程，作好实验准备。

二、进入实验室，要严格遵守实验室各项规章制度，衣着及所携物品符合实验要求，按规定位置就位，不得随意走动或擅自离开。

三、保持室内安静、整洁，不随地吐痰，不乱扔纸屑、乱倒废物及实验产生的废料，不高声讨论，严肃自律，不影响他人实验。

四、实验时要遵从老师指导，遵守操作规程，认真操作，仔细观察，积极思考，努力培养自己分析问题和解决问题的能力。

五、如实记录实验数据，分析实验现象，不得粗心马虎，不抄袭他人实验记录，做完实验认真复查，如有错漏，及时更正或补做。

六、要爱护仪器设备，节约水、电、试剂、药品和器材。凡损坏或丢失仪器、材料、工具等，均应及时报告并登记，按规定处理。

七、实验结束要整理实验台面、收拾实验仪器、器材，打扫卫生。离开实验室时，要注意切断电源、水源、气源，经许可方可离开。

八、按时完成实验报告，认真做好实验后的复习和总结，真正掌握所学知识。

二〇〇三年六月十一日

西北农林科技大学教学实验室评估办法（试行）

办(设)发〔2003〕69号

为进一步贯彻执行《高等学校实验室工作规程》，加强教学实验室的建设与管理，改善办学条件，提高办学水平，充分发挥实验室在教学科研中的作用，根据《高等学校教育评估暂行规定》、《高等学校基础课教学实验室评估办法》及教育部高教司〔2003〕13号文件中有关"基础课实验室每五年复评一次"及"对学校其他教学实验室和专业实验室进行自评估"的要求，制订本办法。

一、评估范围及目的

评估范围为学校正式批准成立的教学实验室。目的主要是通过评估摸清现状，总结经验，找出差距，落实改进措施，加强教学实验室的建设与管理，推动教学实验室在设置、教学、管理、环境、队伍、制度等方面实现规范化、科学化管理，达到国家评估的基本要求。

二、评估原则及重点

以《高等学校实验室工作规程》为指导，遵循以评促建，以评促管，以评促发展的原则，主要从管理及运行角度进行评估，重点看管理、看软件、看运行效果、看实验室工作的规范性、科学性和合理性。硬件只进行基本条件考评，水平高低不作为重点。

三、评估标准及方法

评估依据的标准是教学实验室基本条件合格评估标准，教学质量和实验室水平评估标准暂未列入。评估标准（见《西北农林科技大学教学实验室评估标准》）分为六项30条目，其中重点条目(带*号)13条，一般条目17条。每条有评估内容、评估标准、评估方式、记事、评估等栏目，"记事"栏记录该条目特色或不合格的主要差距等内容，"评估"是指评估组专家进行评估的结果。评估按各条目逐条进行，所有评估条目全部合格的为评估合格；如有一条重点条目或累计五条以内一般条目不合格的实验室，可在二个月内进行整改，整改后申请复评；如有二条重点条目或累计五条以上一般条目不合格的，即为不合格实验室。

四、评估程序及实施办法

(一)宣传、动员,落实任务:

各学院要将评估工作列入工作计划，适时召开实验室主任、有关实验教师及

实验人员会议，宣传、学习评估办法、评估标准及有关评估文件，对本单位评估工作做出具体安排，要发动群众，统一认识，落实任务，按期完成工作计划。

（二）自行评估：各实验室对照《西北农林科技大学教学实验室评估标准》，先进行自查自改，做好实验室教学、管理、设备、人员、环境、安全及有关档案、资料、图表、文字总结等方面的准备工作；各学院按要求组成院级评估组，根据本办法及评估标准规定条目组织自评。学院自评后需形成以下材料：

1. 学院对实验室的自评意见书（按学校统一格式）；

2. 各参评实验室的评估标准表（按学校统一格式，记有各条目的达标结论）；

3. 实验室自评工作报告，主要内容：(1)实验室概况—包括体制、任务、设备、队伍、环境、制度、特色等；(2)自评情况—对评估标准中六项30个条目有一一对应的文字说明；(3)自评结论及建议。

（三）学校评估：学校由主管职能部门牵头，聘请有关专家组成校级评估组，学院自评合格（或自评不合格而即时整改达到合格）后，报校评估组进行校级评估。学校评估组主要工作程序如下：

1. 听取学院汇报本单位整体实验室概况、自评情况及自评结果；

2. 听取实验室主任对本实验室概况、各条目达标情况、自评情况的介绍；

3. 审查各参评实验室的自评材料；

4. 对参评实验室进行实地评估检查（请实验室安排熟悉情况的人员在场引导，并介绍、回答有关问题）；

5. 必要时评估组召开相关人员座谈会，听取对实验室建设与管理的意见；

6. 评估组专家讨论，形成一致意见并向学院和实验室有关人员反馈评估意见。

（四）操作办法：

1. 学院评估组由学院领导、专职教师及实验室管理专家5-7人组成，设组长1人，副组长1人。学校评估组由主管校长、主管部门领导、相关学科的教师及实验室管理专家15-17人组成，设组长1人，副组长2人。

2. 评估采取现场实地考核评估方式，学院或实验室提供有关资料和数据，评估专家按照评估标准逐条进行评审(听、问、考、查)，评估组逐条汇总专家意见，进行统计、审议、确定合格条目数，取得一致意见后，写出评估结论意见书。

3. 对于评估所形成的汇总资料及结论意见，学院自评的由学院及实验室负责存档管理，学校评估的由学校实验室主管部门负责存档管理，有关材料作为以后

实验室建设、管理、评比、表彰等工作的参考依据。

五、评估结果处理

1.经评估，所有条目全部合格的实验室，授予一级合格教学实验室称号，学校予以表彰和奖励；经评估，部分条目未达标，以后通过整改复评达标的，授予二级合格教学实验室称号；校级评估合格的实验室，由学校颁发合格证，评估结果在全校公布。

2.经评估有重要条目未达标，限期整改仍未达标，或在整改期限内未完成整改任务的，均视为不合格实验室，学校对不合格实验室将采取撤消、兼并、更换实验室主任或进一步强化整改等措施进行处理。

3.以后实验室相关经费分配均以管理合格的实验室为对象，凡管理不合格的实验室，整改期间暂停各种经费投入，整改仍不合格，撤消其设置，相关业务并入同学科相近实验室。

4.评估结束，评出全校实验室管理先进集体及先进个人，进行表彰奖励。

二〇〇三年十一月十日

西北农林科技大学教学实验室评估标准（试行）

办(设)发〔2003〕69号

1. 体制与管理

序号	评估内容	评估标准	评估方式	记事	评估
1-1*	实验室的建立	实验室建立经学校正式批准。	查批文,有记Y,无记N。		
1-2	主管领导	有一名院长分管实验室工作，能贯彻执行《高等学校实验室工作规程》。	查学院有关文件和管理资料，有主管院长，能贯彻记Y，否则记N。		
1-3	建设计划	实验室有建设规划及年度工作计划。	查阅实验室建设规划或工作计划。有记Y，无记N。		
1-4	管理体制	实验室属于校、院(系)两级管理体制。	属于校、院(系)级管理的记Y，否则N。		
1-5	管理手段	实验室基本信息、工作档案和仪器设备实现了计算机管理。	查阅实验室或学院计算机管理数据库文件。实现的记Y，否则N。		

2. 实验教学

序号	评估内容	评估标准	评估方式	记事	评估
2-1*	教学任务	有教学大纲或教学计划,承担教学任务量(实验人时数)达到规定标准。	查阅教学大纲、计划、上年度学生实验人时数记录等。达到记Y，否则记N。		
2-2*	实验教材	有正规的实验教材或指导书。	检查所开实验项目的实验教材或指导书。有的记Y，没有的记N。		
2-3*	实验项目管理	每个实验项目管理规范，记载有实验名称、	检查所开实验的项目卡片或计算机管理数		

序号	评估内容	评估标准	评估方式	记事	评估
		面向专业、组数、主要设备名称、规格型号、数量及材料消耗额等。	据库文件。有的记Y，没有的记N。		
2-4	实验考试、考核及实验报告	有考试或考核办法并具体实施。有实验报告，报告有原始实验数据记录，教师签字认可。	检查实验考试或考核办法、成绩记录，抽查学生试卷、实验报告及批改记录。有的记Y，没有的记N。		
2-5	每组实验人数	基础课达到1人1组；专业基础课2人1组；专业课或某些不能1人(或2人)完成的实验，以满足实验要求的最低人数为准。	随机抽查实验课表及实验使用常规仪器套数计算。达到的记Y，达不到的记N。		

3.仪器设备

序号	评估内容	评估标准	评估方式	记事	评估
3-1*	仪器设备管理	单价500元以上的仪器设备账、卡、物相符率达到100％。	抽查10台，以物对卡5台，以卡对物5台。其名称、型号、校编号，完全正确的记Y，不正确的记N。		
3-2*	低值耐用品管理	单价低于500元的低值耐用品，账物相符率不低于90％。	抽查10件账、物校对，其名称、规格、型号、价格，差错不得超过1件，达到的记Y，达不到的N。		
3-3	仪器设备的维修及完好率	仪器设备维修及时。现有仪器设备完好率不低于80％。	检查维修原始记录，抽查5台不同仪器的主要指标。维修及时、非正常仪器不超过1台的记Y，否则记N。		
3-4	大型仪器管理	单价10万元以上的仪器设备有专人管理和技术档案，每台年使用机时不低于400学时。	检查有关报表、技术档案及使用记录，达到记Y，达不到记N，无此项的记0。		

| 3-5 | 教学实验常规仪器配置套数 | 基础及专业基础课常规设备配套数满足实验分组要求；专业课满足实验要求的最低标准。 | 抽查5个实验项目的实验人数、组数及设备配套数，达到要求的记Y，否则记N。 | | |

4. 实验队伍

序号	评估内容	评估标准	评估方式	记事	评估
4-1	实验室主任	实验室主任由学校或学院正式任命或聘任，有高级技术职务，能贯彻《高校实验室工作规程》规定的主要职责。	查任命或聘任文件，是否实行主任负责制，考察有关工作资料、记录。符合记Y，否则记N。		
4-2*	专职人员	实验室有3人以上专职技术人员，符合学校定编，满足工作需要。	实际考察并结合有关统计报表分析确认。达到记Y，否则记N。		
4-3	人员结构	专职人员中，高级技术职务人员及参加实验的教师符合规定的比例及人数。	实际考察并结合有关统计报表分析确认。达到记Y，否则记N。		
4-4	岗位职责	实验室主任、技术人员和工人有岗位职责及分工细则，专职技术人员每人有岗位日志。	检查岗位职责文件，现场考察人员分工落实情况。达到记Y，否则记N。		
4-5	人员培训考核	实验室或学院对实验人员有培训计划、考核办法，定期考核。	检查计划、办法和考核材料。有的记Y，没有的记N。		

5. 环境与安全

序号	评估内容	评估标准	评估方式	记事	评估
5-1	学生实验用房	实验室无危漏隐患，门、窗、玻璃、锁、扣完整无缺，墙面干	现场考察，检查实验室使用面积和容纳学生人数，达到的记Y，达		

序号	评估内容	评估标准	评估方式	记事	评估
		净无污损。生均实际使用实验面积不低于2m²，实验台、凳、架无破损，符合规范。	不到记N。		
5-2*	设施及环境	实验室的通风、照明、控温、控湿等设施完好。电路、水、气、管道布局安全、规范。	现场考察，达到的记Y，达不到的记N。		
5-3*	安全措施	实验室有防火、防爆、防盗的基本设备和措施。实验操作室、办公室、值班室分开。走廊不得存放自行车及生活品。	检查消防器材和三防措施，查操作室、办公室、值班室是否分开。达到的记Y，否则记N。		
5-4*	特殊技术安全及环境保护	对高压容器、气瓶、病菌、实验动物、放射性物品、危险品、剧毒品、三废品等有存放、使用、管理、处置的办法和措施，符合有关行业要求及规定。	实际考察，相关项目有证件、有措施，达到基本要求或不造成公害。全符合的记Y，否则记N。无此项内容的记0。		
5-5*	整洁卫生	室内家具仪器摆放整齐，布局合理。仪器、桌面、地面无尘土、积水、纸屑等垃圾。墙面、门窗、管线上无积灰、蛛网等。	现场实际考察实验室及室外走廊等处确认。符合的记Y，不符合的记N。		

6. 管理规章制度

序号	评估内容	评估标准	评估方式	记事	评估
6-1*	物资管理制度	实验室有仪器设备管理制度、实验仪器损坏丢失赔偿制度、低值耐用品管理办法。	现场实际考察，有制度并挂在墙上或放在明显处。有的记Y，不全的记N。		

6-2*	安全检查制度	有安全制度，成文挂在墙上，专人定期进行安全检查。	检查有无制度和安检记录。有的记Y，不全的记N。		
6-3	学生实验守则	实验室有学生实验守则，学生能遵守。	现场调查有无守则及学生遵守情况。确定Y或N。		
6-4	工作档案管理制度	遵守学校实验室工作档案管理制度并认真实施。	按学校实验室档案管理要求，检查实验室档案收集整理情况，基本完成的记Y，否则记N。		
6-5	基本信息的收集整理制度	实验教学、实验任务、实验人员等基本信息的收集整理，能执行学校有关制度，如期汇总上报。	检查收集整理情况，看是否执行了学校有关制度并完成了上年度有关报表。完成的记Y，否则记N。		

教学实验室评估标准有关条目说明

1-3 建设计划：其中建设规划指学院内部的规划，查阅学院近1-2年的实验室建设规划或学院文件中含有实验室建设规划部分。

2-1 教学任务：语音教学中心不低于500000人时数，计算机实习中心不低于150000人时数，其它基础及专业基础课实验室不低于64800人时数，专业实验室不低于21600人时数。对个别因招生规模和专业特点达不到基本人时数，但实验室已承担全校相关专业的全部同类实验教学任务，且其它条目均合格者，可视为达到工作量指标。人时数含计划内、计划外、研究生和其它实验教学任务。

2-3 实验项目管理：有以下三者之一即可：(1)实验项目卡片(有实验名称、面向专业、组数、主要设备名称、规格型号、数量及材料消耗额等)；(2)具备(1)所述各项内容的教材、指导书；(3)计算机项目管理数据库。

2-4 实验考试、考核及实验报告：查实验的考试或考核办法，近1-2年学生成绩记录或试卷，二者有一即可；实验室准备近一年两个实验内容的实验报告（计算机、语音实习有阶段性实验报告）各不少于20份。评估组从中抽查3份。

3-1 仪器设备管理：借出的要有完备的手续，附件要在卡片上记载完整。

3-3 仪器设备维修：以不影响实验教学任务的正常进行即为"及时"，一般10万元以上大型仪器维修期不超半年，其它仪器不超过一月。检查近1-2年仪器设备损坏维修记录及记载的维修设备名称、维修主要内容、时间、维修人签字等。

4-2 专职人员：教师编制的实验室主任和年均2/3以上工作量在实验室的教师，可按专职实验技术人员计算。

4-3 人员结构：基础课及专业基础课实验室专职人员中，高级技术职务人员占20％以上，参加实验的教师比专职实验人员多2倍以上；专业课实验室专职人员中高级技术职务人员占10％以上，参加实验的教师不少于专职实验人员数。

4-4 岗位职责：至少从自评开始，实验室专职人员需要有岗位日志。

5-4 特殊技术安全及环境保护：1.高压容器存放合理，易燃与助燃气瓶分开放置；2.使用放射性同位素的有许可证、上岗证；3.使用有害射线的有超计量检测手段；4.对病菌、实验动物有管理措施；5.对重要危险品、剧毒品有领用管理办法；6.对三废品（废气、废液、废渣）有处理措施，噪音小于70dB。

6-4 工作档案管理制度：至少应从自评开始建立，有按学校实验室档案管理制度要求整理的材料。

6-5 基本信息的收集整理制度：要认真执行学校有关制度，能保证信息的连续性，有执行情况的材料。

<div align="right">二〇〇三年十一月十日</div>

西北农林科技大学大型、精密、贵重仪器设备联合评议工作管理办法（试行）

校实验发〔2004〕300号

第一章 总 则

第一条 根据财政部、科技部、教育部、中国科学院等单位联合发布的《中央级新购大型科学仪器设备联合评议工作管理办法》，结合我校实际制订本办法。

第二条 单价10万元人民币（含10万元）以上，用于教学实验、科学研究和技术开发的单台或成套仪器设备，均属于大型、精密、贵重仪器设备。

第二章 评议机构与范围

第三条 由实验室管理处、国有资产管理处、科研处、计财处等部门及有关专家联合成立西北农林科技大学大型、精密、贵重仪器设备联合评议工作组（以下简称工作组），组长由一名副校长担任。

第四条 工作组负责全校大型、精密、贵重仪器设备联合评议工作。工作组办公室设在实验室管理处，负责日常组织和管理工作。

第五条 西北农林科技大学所有教学、科研、行政及企事业单位，申请省部级以上科研、推广、教学经费支持，购置价格超过10万元（含自筹部分）的单件或成套大型、精密、贵重仪器设备，除另有规定外，均列入联合评议范围。

第六条 学校鼓励教学、科研人员使用科研经费购置大型、精密、贵重仪器设备。

第三章 评议程序和内容

第七条 申请购置大型、精密、贵重仪器设备的单位，按照《西北农林科技大学大型仪器设备管理办法》进行可行性论证，提交申购报告报实验室管理处。

第八条 工作组按照"统筹规划、合理配置、资源共享"的原则对所申购仪器设备的必要性、可行性等进行评议并提出具体评议意见。

第九条 评议内容

（一）绩效目标及其合理性：新购仪器设备的利用率、预计用户数量、对外开放时间；科研工作需求程度、购置的预算方案和项目实施管理能力等；

（二）申购仪器设备对学科发展的意义和必要性；

（三）仪器设备功能、指标的先进性及适用性；

（四）国内外同类设备性能、价格比较；

（五）申请单位现有大型仪器设备使用情况及绩效考核结果；

（六）申购仪器设备的安装及技术队伍等配套保障条件；

（七）申购仪器设备的共享、共用方案；

（八）申购仪器设备附件、零配件、软件配套经费及运行经费等的落实情况。

第十条 由实验室管理处及时将工作组联合评议结果及时通报申购单位和计财处等学校相关部门。

第十一条 计财处和有关部门以评议意见为依据，下达经费或编制计划、履行采购。未经评议程序的新购预算方案不予立项。

第四章　管　理

第十二条 学校主管大型仪器设备的有关部门应认真执行财政部、科技部、教育部、中国科学院等部门联合发布的《中央级新购大型科学仪器设备联合评议工作管理办法》，逐步建立和完善大型仪器设备共享机制，制订有利于大型仪器设备共享的规章制度或规范性文件，建立大型仪器设备资源库及相关的信息管理系统，定期发布大型仪器设备可利用资源的有关信息。

第十三条 根据大型仪器设备使用情况，学校将出台相关办法逐步解决大型仪器设备开放共享中的运行与维修费用。

第十四条 大型仪器设备依托单位应采取有效措施，保证大型仪器设备的完好运行，促进大型仪器设备充分、高效利用。在优先保证完成科学研究任务的前提下， 积极向社会开放，尤其要优先向经联合评议未同意购置大型仪器设备的单位开放， 并提供优质服务。

第十五条 大型仪器设备依托单位应加强对大型仪器设备的运行状况及相关技术支撑人员的考核，建立考核档案，并将考核结果报实验室管理处和工作组备案。

第十六条 实验室管理处会同科研处对有关单位配套资金落实情况、预算执行情况、经费情况等进行监督检查。对经评议后购置的大型设备结合立项绩效目标， 定期进行考核，并建立相应的考评档案。考评结果作为相关单位下一轮项目立项的重要依据。

第五章　附　则

第十七条　本办法由实验室管理处负责解释。

第十八条　本办法自发布之日起执行。

附：西北农林科技大学大型精密贵重仪器设备论证报告

二〇〇四年十一月二十六日

西北农林科技大学实验教学工作规范

校教发〔2005〕179号

实验教学是课堂教学的继续，是对学生进行基本技能训练的主要环节。实验教学的基本任务是加深和巩固理论知识，使学生掌握实验的基本原理、基本方法、基本操作和基本技能，获得独立测量、观察、处理实验数据，分析实验结果，书写实验报告等能力，培养学生分析解决问题、独立进行科学实验研究的能力和严谨的科学态度。为了更好的组织实验教学，不断提高实验教学质量，结合我校实际情况，特制定本规范。

一、实验准备

1、实验室（或教研室）应根据教学大纲的要求编写实验大纲，开出规定的实验项目，选定或编写合适的实验教材。

2、实验课指导教师接受授课任务后，要认真备课，必须亲自对开出的实验项目进行实际操作，测量完整的数据，观察、分析和处理实验结果。

3、实验室（或教研室）应按教学要求组织集体备课，教师应认真编写教案，规范实验教学内容。对每一个实验项目，要写明实验的目的与要求、实验原理、实验用仪器设备及操作方法，学生在实验中容易出现的困难及错误，仪器设备可能出现的异常现象及处理方法，实验的结果、数据处理和误差分析。

4、做好实验用仪器设备、材料的准备与检查，检查安全设施，消除事故隐患。

5、主讲理论课的教师必须经常了解实验教学情况，主动与实验课教师配合，防止理论与实际脱节。

6、综合性实验、设计性实验要求参照《西北农林科技大学关于开设综合性、设计性实验实施办法》执行。

7、实验室应积极探讨改进实验教学方法，不断完善实验教学手段，不断充实更新实验内容，开展实验教学方法、试验技术、实验装置改进等方面的研究，及时研究解决实验教学中的问题。积极开设新实验、设计性实验和综合性实验，实验室进行开放式管理，切实加强对学生的创新精神和实践能力的培养。

二、上课

1、实验课教师应向学生清楚阐述实验原理、操作规程以及实验教学要求。

实验示范操作熟练、规范，正确掌握时机。确保实验教学的效果和实验安全。

2、实验过程中应加强巡查指导，观察、记录和评定学生操作情况。严格要求学生遵守实验规则，精心使用器材，培养学生严肃的科学态度和严谨的工作作风。

3、教师应结合教学内容启发诱导，激发学生主动参与教学活动的热情，认真指导学生基本技能操作，培养学生的动手能力和独立观察、分析、处理问题的能力。

4、实验过程中，指导教师要做到全方位掌握学生操作（实验）情况，不断启发学生，坚持严格要求，指导学生认真做好实验记录和书写实验报告。

5、实验课堂其它要求参照《西北农林科技大学教师课堂教学规范》执行。

三、考核

教师对学生的实验报告进行认真批阅，对存在的问题进行及时讲评，建立起完善的实验课程考核体系。具体可参照《西北农林科技大学考试工作条例》执行。

四、本规范从下发之日起起施行，由教务处负责解释。

二〇〇五年五月八日

西北农林科技大学关于开设综合性、设计性实验的实施意见

校教发〔2005〕224号

实践教学是培养学生创新能力、创新精神和团队合作精神的有效途径，我校在人才培养过程中，始终贯彻产学研结合的办学指导思想，把加强实践教学作为实施学生素质教育的重要基础。为了使开设综合性、设计性实验工作制度化、规范化，进一步提高学生实践能力和创新能力，特制定本实施意见。

第一条　目的和意义

开设综合性实验的目的在于培养学生的综合分析能力、实验动手能力、数据处理能力及查阅中外文资料的能力。设计性实验是开发学生智能的重要步骤，着重培养学生独立解决实际问题的能力、探索创新能力及组织管理能力。

第二条　综合性、设计性实验的界定

综合性实验：是指实验内容涉及本课程的综合知识或与本课程相关课程知识的实验。是学生经过一个阶段的学习后，具有一定知识和技能的基础上，运用某一门课程或多门课程的知识对学生实验技能和方法进行综合训练的一种复合型实验。综合性实验一般可以在一门课程的一个循环之后开设，也可以在几门课程之后安排一次有一定规模的时间较长的实验。

设计性实验：是指给定实验目的要求和实验条件，由学生自行设计实验方案并加以实现的实验。它不但要求学生综合多门学科的知识和各种实验原理来设计实验方案，而且要求学生能充分运用已经学到的知识，去发现问题，解决问题。设计性实验一般是在学生经过常规和综合性实验训练，经历了一个由浅入深的过程之后开设。开始时可由指导教师出题目，给方案，由学生自己拟定步骤，自己选定仪器设备，自己绘制图表等。更进一步的设计性实验则在指导教师出题后，全部由学生自己组织实验，甚至可以让学生自己选题，自己设计，在教师的指导下进行，以最大限度发挥学生学习的主动性。

第三条　开设综合性、设计性实验的课程范围

在保证所有实验课程的实验开出率为100%的情况下，凡有实验的主要基础课和专业基础课都应开出综合性、设计性实验，其他有实验的主要专业课也应创造条件开出综合性和设计性实验。确保有综合性、设计性实验的课程占有实验课程总数的比例不小于80%。

学校各开放实验室必须为学生进行综合性、设计性实验创造条件，鼓励学院开设综合性、设计性实验的公共选修课。

第四条 实施程序及有关规定

由课程负责人和教研室提出拟开设综合性、设计性实验的申请，填写《西北农林科技大学综合性、设计性实验开设登记表》，经学院院长审定后报送教务处教学管理科和实验室管理处。

凡经批准开设的综合性、设计性实验，必须提出详细的实验指导书、任务书报教务处和实验室管理处，教务处和实验室管理处将组织有关专家检查实验项目执行情况。

本意见自公布之日起施行，由教务处负责解释。

二〇〇五年五月二十七日

西北农林科技大学本科生教学实习工作规范

校教发〔2005〕225号

教学实习是本科专业人才培养过程中一个重要的实践性教学环节，是学生巩固专业知识，促进理论与实践相结合，提高专业技能的重要教学环节。为了加强对实习工作的管理，不断提高实习质量，特制定本规范。

第一章　实习的目的和要求

第一条　实习的目的是让学生通过各类实习接触实际和了解社会，获取本专业的实际工作技能，巩固所学理论知识，培养初步的实际工作能力和专业技能。具体要求如下：

1．了解社会和实习场所的一般情况，增加对本学科专业领域的感性认识；

2．初步了解所学专业在国民经济建设中的地位、作用和发展趋势；

3．巩固、深化所学理论知识，培养分析和解决实际问题的初步能力；

4．熟悉专业技术人员的工作职责和工作程序，获得组织和管理生产的初步知识；

5．虚心学习，培养热爱专业、热爱劳动的品德。

第二章　实习的组织领导

第二条　教务处宏观协调全校的教学实习，并负责督促、检查工作。学院负责具体组织管理工作。实习过程中，实行带队教师全面负责制，学生党、团组织和班委会要充分发挥作用，努力搞好各项工作。

1．教务处职责

（1）组织制订和审核实习教学大纲；

（2）汇总和审核各教学单位制定的年度实习计划；

（3）检查各教学单位实习前的准备工作和实习计划的执行情况，协调解决全校实习中的有关问题；

（4）检查考核实习质量，组织实习工作总结和经验交流等；

（5）组织开展实践教学研究，提高实践教学质量。

2．院（系）职责

（1）按照专业人才培养目标的要求组织编写专业技能规范和实习教学大纲；

（2）具体负责实习基地建设和实习场所的联系与确定，根据实习目的和要求，做出具体的实习安排；

（3）建立实习队组织，选派实习队负责人和实习指导教师，并考核他们的工作；

（4）负责实习前的组织动员，检查实习队的准备工作和实习计划的执行情况，实习结束后及时组织实习工作总结；

（5）检查考核实习质量。实习结束后，组织院（系）内实习经验交流会；

（6）每年 11 月底以前将下年度实习计划报教务处；

（7）组织教师开展实习内容、方式、方法的改革与研究。

第三章　实习计划和实习安排

第三条　各院（系）要在实习前进行实习动员，明确实习的目的、内容和要求，并针对本次实习的特点，进行实习态度、实习纪律和实习安全等方面的教育。

第四条　各院（系）应根据各专业培养计划的要求制定详细的实习计划，经主管院长（系主任）审核签字后报教务处审批。各专业学生实习应严格按实习计划执行，如遇特殊情况需要更改实习时间，变动实习地点或取消实习计划，应书面说明原因，经主管院长（系主任）签字后报教务处审批，否则，按教学事故处理。

第五条　实习安排是组织和检查实习的主要依据。各院（系）应根据各专业培养目标和教学计划，认真组织做好实习安排，并于实习开始前 2 周报教务处。实习安排的内容包括以下几个方面：

1. 实习的目的、要求和场所；

2. 实习的内容和检查方法；

3. 实习方式和时间分配；

4. 实习期间的现场教学和跟班劳动安排；

5. 实习成绩的考核内容和考核方法。

第六条　为提高实习效果，各院（系）应组织有关教师根据实习教学大纲的要求编写实习指导书，详细说明实习要求和完成实习大纲规定内容的办法，指导学生实习。

第四章　实习场所和实习方式

第七条　　选择实习场所应满足实习大纲的要求并力求相对稳定，提倡和鼓励各专业在实习单位建立教学、科研和生产三结合的实习基地。选择实习场所时应考虑以下原则：

1. 专业基本对口，能满足实习大纲的要求，便于实习安排；

2. 生产正常，技术、管理较先进，对学生实习支持和重视；

3. 尽可能就地就近，相对稳定。

第八条　　实习可以根据专业特点和实习场所的实际情况，采取多种方式进行。既可以班级为单位集中安排，也可以将班级分为若干小组分散进行。考虑到目前学生外出实习难于动手的实际，还可以采取校内外相结合进行生产实习的尝试。无论采用何种方式实习，都要满足实习教学大纲要求，保证实习质量。

第五章　　实习指导教师

第九条　　实习指导教师应由教学经验丰富、对生产实际较为熟悉、了解实习点的基本情况、工作责任心强、有一定组织管理能力的中级及以上职称教师担任。为了保证实习质量，刚毕业任教的本科生、研究生不能单独指导学生实习；对于初次承担指导实习任务的教师，院（系）应指定专人进行指导，可提前到实习点准备。

第十条　　指导教师的职责

1. 提前了解实习单位情况和学生实习要求，会同实习单位有关人员根据实际情况制定详细的实习安排，并做好劳保、工具和经费等实习相关准备。

2. 按实习大纲和实习安排的要求，安排、落实各项实习工作，与实习单位配合及时解决实习中的问题。

3. 在实习中对学生要加强指导，严格要求，组织好各种教学和参观活动，积极引导学生深入实际，检查督促学生完成各项实习任务。

4. 指导教师要以身作则，言传身教，既教书又育人，注重对学生进行安全教育，全面关心学生的思想、学习、生活和健康。

5. 检查实习纪律执行情况，及时处理学生违纪问题。

6. 定期向实习单位领导汇报实习情况，争取他们的指导和帮助。可根据实习单位的需要组织学生参加公益活动和义务劳动。实习结束，离开实习单位前要做好与实习单位的交接工作。

7. 指导学生写好实习报告，负责学生实习成绩的考核和评定工作。

8. 实习结束后 1 周内写出实习工作总结并向学院(系)汇报。

第六章　　对学生的具体要求

第十一条　　实习中学生必须做到以下各点：

1. 必须服从带队教师和实习小组的领导。

2. 必须接受实习指导教师的指导，按实习教学大纲、实习安排的要求和规定完成实习任务，要重视在实践中学习，记好实习笔记，按时完成实习思考题或作业，并结合自己的体会写好实习报告。

3. 尊重实习单位工作人员的劳动，虚心向他们学习。主动协助实习单位做一些力所能及的工作。

4. 学生在实习期间不得迟到、早退或窜岗。有事或因病(凭医生证明)离开实习岗位须经指导教师批准并办理请假手续，否则按旷课处理。

5. 实习期间应注意安全，不得参与同实习无关的工作，不得去江、河、湖、海中游泳。

6. 遵守实习单位和实习队的各项规章制度。

第七章　　分散实习的管理

第十二条　　分散实习是由院（系）安排或学生自主联系分散到相关单位进行实习的一种实习方式。根据专业特点和培养要求，对进行分散式实习的学生，学校实行目标管理。各院（系）要加强组织领导，制定相应的实习教学大纲、详细的实习要求和具体的实习成绩考核办法，有条件的可委托实习单位代为管理。分散实习管理的主要内容包括：

1. 实习学期的前一学期末，实习指导教师应把实习大纲和实习基本要求发给学生，学生利用假期就近联系实习地点，开学后将联系结果报告指导教师。

2. 如果条件允许，指导教师按学生的联系结果进行必要的调配后编组（每组尽可能不少于三人）并指定组长（副组长）；对于自己联系有困难的学生，由指导教师负责在本地（市内）联系实习单位。

3. 必要时，指导教师应前往实习学生较集中的地区进行巡回检查、指导。

4. 在实习期间，学生应按实习大纲、实习计划进度的要求和规定认真地完成实习任务，认真填写实习日记，如实反映每天的主要实习内容、实习收获、出现的问题及解决问题的方法，并结合自己的实习及体会写好实习报告。

5. 实习期间应严格遵守实习所在单位的上、下班制度、安全制度、操作规程、保密制度及其它各项规章制度。

6. 实习结束前，学生应对本次实习进行认真总结，如实填写学生实习成绩考核鉴定表，并请实习单位或实习单位指导人员在鉴定表中出据实事求是的实习鉴定。

第八章　　实习考核与成绩评定

第十三条　　根据专业特点和实习类型的不同，各院（系）在组织各类实习时应制定详细的考核标准和切实可行的考核办法。考核内容应包括：思想政治表现、劳动态度、组织纪律、实习任务完成情况、实习日记、实习报告和实际操作水平等。

第十四条　　按实习大纲要求，集中实习的学生必须完成实习的全部任务并提交实习日记和实习报告后，方可参加考核。

第十五条　　分散实习的考核

1. 分散实习注重目标管理，因此，考核工作必须严格要求，认真做好，原则上分散实习的考核工作应在实习回校后立即进行。

2. 分散实习的学生，实习结束后，学生必须完成实习的全部任务并提交实习报告、实习日记、实习单位或实习单位指导人员的鉴定方可参加考核。

3. 考核小组应由实习指导教师、系（教研室）负责人、辅导员及学院（系）负责人等组成；考核可采用实习答辩的形式进行，每位学生实习答辩以 15 分钟为宜。除实习答辩外，各院（系）根据需要还可增加笔试对学生实习进行考核。

第十六条　　实习成绩按优秀、良好、中等、及格和不及格五级制评定。

第十七条　　实习期间因故请假累计超过实习时间的三分之一者，应令其补足或重新实习，否则，其实习成绩按不及格处理；对不请假或请假未批准不参加实习者，以旷课论处，旷课时间累计超过实习时间四分之一者，实习成绩为不及格；实习期间，因违反规定或安全制度，出现重大责任事故者，实习成绩为不及格。因实习成绩不及格而补做实习所需费用，一律由学生个人自理。

第九章　　实习工作总结

第十八条　　实习结束后，各实习教学单位要认真做好实习工作总结和经验交流，如实填报实习工作总结，于实习结束后 2 周内将实习工作总结交教务处。

第十九条　　本规范自发文之日起执行，由教务处负责解释。

西北农林科技大学青年教师导师制实施办法

校人发〔2005〕340号

为了进一步加强青年教师的培养，充分发挥具有丰富教学经验教师在教学和科研中的示范和帮带作用，提高青年教师的思想素质和业务素质，建立一支高水平的青年教师队伍，特制定青年教师导师制实施办法。

一、指导思想

1、帮助青年教师尽快适应高校教学工作，尽快融入教师队伍。

2、提高青年教师教学水平，保证人才培养质量。

二、实施对象

35周岁以下（含）的青年教师，有下列情况之一者，必须配备指导教师。

1、新接收的青年教师。

2、具有助教专业技术职务的教师。

3、转到教师系列工作不满一年的教师。

三、基本要求

导师通过指导青年教师参与课堂教学示范和精品课程建设等教学活动，使指导对象了解课堂教学的基本方法、要求和标准；青年教师应在导师指导下完成随班听课、课后辅导、批改作业、试讲、辅助实验指导、参与科学研究等教学与科研环节。

四、导师基本条件

1、具有副教授以上专业技术职务，教龄在10年以上。

2、具有丰富的教学经验和良好的教学效果，师德高尚，治学严谨，学术造诣较深。

3、能履行本实施办法所规定的导师工作职责。

五、导师工作职责

1、进行师德教育，传授科学的教育思想，培养青年教师实事求是、严谨踏实的科学态度和敬业精神。

2、指导青年教师至少掌握一门课程的教学内容、教学要点以及与本课程相关学科的前沿知识，培养其从事教学、科研的能力，吸收青年教师参与科研工作。

3、指导青年教师撰写讲课提纲和教案，掌握正确的教学方法，熟悉并把握

教学环节和教学规范。

4、结合授课的内容和特点，运用各种教学手段和现代教学技术，指导青年教师进行教学改革实践，提高教学质量。

六、导师聘任

采用双向选择原则，由各学院（系、部）确定导师与被指导青年教师，并自行聘任。

七、指导时间

青年教师导师制采用聘任制，聘期1年至2年。其中本科毕业生的带教指导期为2年，硕士毕业生的带教指导期为1年，博士毕业生的带教指导期为半年。带教期满可根据实际情况申请延长。

八、考核与相关规定

1、青年教师导师制由各学院（系、部）负责具体实施。

2、为保证导师制培养质量，每名导师原则上每次指导青年教师不超过两名。

3、在指导期间的每年12月初各学院依据学生对青年教师评教结果、教学督导组听课结果、教学活动评比结果、参加精品课程建设等方面内容对导师指导青年教师工作进行考核，考核分为优秀、合格和不合格三类，学院自定考核办法，优秀比例控制在20%以内。各学院考核后将结果报人事处备案。学校根据考核结果按优秀每人每年1000元、合格每人每年500元的标准为指导教师发放指导费。

4、指导期满后，由学院组织专家通过试讲、评议教案等方式对青年教师主讲课程的能力、水平和教案质量进行考核，考核分为优秀、合格和不合格三类。考核合格以上报人事处备案。青年教师晋升专业技术职务和进修学历（学位）须在合格以上。

5、教授、副教授指导青年教师是本职工作的一部分。学校将青年教师的指导工作做为教师系列高级专业技术职务评审的必备条件，申报教授职务需有指导青年教师的经历。

九、其它

本办法从发文之日起执行，由人事处负责解释。

二〇〇五年九月六日

西北农林科技大学教学实验室工作人员管理办法

校实验发〔2005〕142号

第一章 总 则

第一条 为了促进我校教学实验室建设,提高教学实验室管理水平,建立高素质的实验室工作人员队伍，按照教育部《高等学校实验室工作规程》、《高等学校本科教学工作水平评估标准》，结合我校实际，特制定本办法。

第二条 教学实验室工作人员指从事实验室工作的教师、实验室技术人员、实验室管理人员和工人。

第三条 教学实验室工作人员分为专职和兼职两类。专职工作人员是指全学年2/3 以上时间在实验室工作的在编实验室人员；兼职工作人员是指全学年 1/3 以上时间不在实验室工作的人员。

第二章 队伍建设

第四条 实验室主任由熟悉实验室工作、具有副高级以上专业技术职务的在岗人员担任，并且由学校或学院聘任或任命。

第五条 实验室工作人员实行聘任制，按工作量大小定编定岗，每个实验室专职工作人员应在 3 人以上，其中具有高级专业技术职务者占 30%以上。

第六条 教学实验室工作人员应具有大学本科以上学历，特殊岗位可适当放宽学历条件。

第三章 工作职责

第七条 实验室主任配合上级部门做好实验室的检查、评估和考核工作。实验室工作人员在实验室主任的领导下，按照岗位职责完成本人所承担的工作。

第八条 专职工作人员必须做好教学实验的准备工作，保证实验教学工作的顺利进行。

第九条 实验课教师必须不断改革实验教学方法，在常规实验方法基础上，增加设计性和综合性实验，启发和引导学生的创新思维。

第十条 鼓励实验室人员在充分利用现有仪器设备的前提下，不断探索和挖掘设备潜力，并结合教学实验实际研发教学仪器设备。

第十一条 实验教师和仪器设备管理人员应认真填写实验室日志和仪器设备运行状况,及时向实验室主任汇报存在问题，并提出解决方案。

第十二条 实验室档案管理人员要及时收集、整理、归档有关文件和资料，使实验室从设立到归并有据可查,设备要有验收、使用、维修、借还等记录。

第十三条 实验室管理员根据有关部门安排，按时完成教育部年度报表和网上实验室数据的传输工作。

第十四条 实验室工作人员应做好本实验室的仪器设备管理工作，做到帐、卡、物相符，同时负责本实验室的安全、环境卫生等日常工作。

第四章 管 理

第十五条 实验室工作人员参照学校有关规定进行管理。

第十六条 实验室工作人员的调入，由拟调入人员提出书面申请，所在单位和实验室管理处签署同意调入意见，报人事处审批，办理内部调动手续。

第十七条 实验室工作人员调离时，必须按要求移交有关手续。承担重要任务的实验室人员应保证接替工作人员到位后，方可办理调离手续，并在实验室管理处备案。

第五章 培训、考核和晋升

第十八条 实验室工作人员在完成本岗位工作的前提下，根据工作需要，服从实验室主任的安排，完成培训和进修任务。

第十九条 在不影响正常工作前提下，鼓励实验室工作人员在职攻读硕士、博士学位。

第二十条 根据学校有关规定，每年度对实验室工作人员进行工作量考核，并依工作量大小核发岗位津贴。

第二十一条 实验室工作人员的考核参照学校有关规定进行，考核结果作为个人专业技术职务晋升和聘任的依据。考核优秀者，在同等条件下可优先申报或推荐参加高一级专业技术职务的评审；连续两年考核不合格者，予以解聘。

第二十二条 实验室工作人员参照学校有关规定晋升专业技术职务；实验技术人员参加实验系列专业技术职务评审，该系列设正高级实验师。

第六章 奖 惩

第二十三条 学校每学年对实验室先进工作者予以表彰。每两年进行一次实验技术成果奖的评审工作。

第二十四条 实验室工作人员违反学校有关规定和管理制度，应进行批评教育； 情节严重者，按照学校有关规定进行处罚。

第七章　附　则

第二十五条　本办法自公布之日起执行。

第二十六条　本办法由实验室管理处负责解释。

二〇〇五年三月三十一日

西北农林科技大学教学实验室管理办法

校实验发〔2005〕270号

第一章 总 则

第一条 为了加强我校教学实验室的建设和管理，保证正常实验教学秩序，提高实验室管理水平和办学效益，根据教育部《高等学校实验室工作规程》，结合我校实际，制定本办法。

第二条 教学实验室必须认真贯彻国家的教育方针，坚持以培养高素质、全面发展的创新型人才为重点，积极进行实验教学改革与创新，不断提升实验教学水平和质量。

第三条 实验室建设要从实际出发、统筹规划、资源共享、合理设置，做到建筑设施、仪器设备、实验队伍与科学管理协调发展，提高投资效益。

第四条 本办法所指实验室是指学校正式批准，以实验教学和实验教学改革与创新为主要任务的教学实验室。

第二章 基本任务

第五条 根据学校实验教学计划的要求完成实验教学工作，负责制定和完善实验教学大纲，按计划准备和开出实验课程，负责完善实验指导书或实验讲义等，配备、安排指导教师和实验室工作人员，保证实验教学任务的顺利完成。

第六条 积极开展实验教学研究与创新，努力提高实验教学水平和质量；不断吸收教学和科研工作的新成果，更新实验内容，改革实验教学方法，逐步增加综合性、设计性实验比例。

第七条 各实验室应积极创造条件，面向学生进行开放，鼓励学生自主设计实验， 培养学生的创新意识和实践能力。

第八条 做好仪器设备的管理工作，保证帐、物、卡完全相符，接受上级主管部门对资产的清查；做好仪器设备的维护、维修工作，使仪器设备经常处于良好状态， 完好率保持在 90％以上；不断挖掘仪器设备潜力，研究、改造、自制实验装置，满足实验教学发展的需要。

第九条 严格执行实验室的各项工作规范，加强对实验室工作人员的培训和管理； 做好实验室基本信息收集、统计、上报工作和实验室安全及技术档案的

管理工作。

第三章　设置

第十条　实验室设置要以学生规模、专业设置、学科建设及实验教学计划为依据，既要满足实验教学需要，又要兼顾专业间的交叉与融合，体现特色，避免重复设置。

第十一条　实验室设置应当具备以下基本条件：

（一）有稳定的专业发展方向和饱满的实验教学任务；

（二）有符合实验技术要求的房舍、设施及环境，生均实验室面积不低于 2m2，三废排放、水电及防火要符合安全及环保要求，噪音应小于 70dB；

（三）有足够数量、配套齐全的仪器设备，大型设备及系统装置按实际需求配置，常规仪器台（套）数符合教育部有关要求；

（四）有合格的实验室主任和 3 人以上专职实验室工作人员，其中高级技术职务人员占 30％以上；

（五）有可行性论证报告、长远发展规划、近期建设计划及完善的内部管理制度。有条件的院(系)可根据需要设立实验教学中心、中心实验室或综合实验室。

第十二条　实验室调整、合并与撤消要根据专业调整、实验教学需求，由院（系）提出申请，实验室管理处组织论证，提出调整、合并或撤消意见，报主管校长批准，学校正式发文。

第四章　建设

第十三条　实验室建设纳入学校总体发展规划，需考虑环境设施、仪器设备、人员结构、经费投入等综合配套因素，按照立项、论证、实施、监督、竣工、验收、效益考核等"项目管理"办法的程序，由实验室管理处统一规划。

第十四条　实验室建设应按计划进行；其中房舍、设施及大型设备要依据规划的方案纳入学校基本建设和专项建设计划；一般仪器设备更新、补充和运行、维修费用纳入学校财务计划；工作人员的配备与结构调整纳入学校人事计划。

第十五条　实验室建设需调动各方面的积极性，多渠道筹措资金；学校每年安排一定数额资金、各院（系）也应积极筹措资金用于实验室建设，同时依靠专业优势积极与校外单位以合作、共建等方式进行实验室建设。

第十六条　实验室建设提倡和支持修旧利废、自制仪器设备及开发实验设备

功能。

第五章　管理体制

第十七条　学校由一名副校长分管实验室工作，实验室实行校、院（系）二级管理。

第十八条　实验室管理处是学校主管实验室工作的职能部门，负责组织实施实验室的建设和管理。其主要职责是：

（一）贯彻执行国家有关方针、政策和法令，结合实验室工作实际，制定相应管理办法，并负责组织实施；

（二）负责组织制定教学实验室发展规划和年度建设计划，归口管理实验室建设专项经费和仪器设备，并进行投资效益评估；

（三）负责实验室仪器设备购置计划的审核、大型仪器设备可行性论证及资源共享；

（四）组织和推进实验装置的研究与开发，促进教学实验水平的提高；

（五）做好实验室安全工作，组织实施实验室工作的评估、评比和表彰；

（六）配合人事部门做好实验室人员定编、岗位培训和考核工作。

第十九条　实验室管理由院（系）主管院长（主任）负责组织实施，主要职责是：

（一）贯彻执行国家、学校有关政策法令和制度；

（二）制定本院（系）实验室管理制度；

（三）负责制定并组织实施本院（系）实验室年度建设计划；

（四）负责安排并组织实施本院（系）实验教学及有关工作任务；

（五）做好本院（系）实验室队伍建设，组织实施实验室工作人员考核和评聘工作；

（六）组织本院（系）实验室按时上报各项统计报表，完成学校安排的各项任务。

第六章　管　理

第二十条　各实验室要认真贯彻国家有关实验室的工作法令、法规，实行科学管理，利用计算机对实验室人员、物资、经费、环境等进行记录和分析，及时准确地提供各类信息；按照实验室建设与评估标准，定期检查评估，对存在问题及时整改。

第二十一条　要建立、健全实验室工作岗位责任制，定期对实验室工作人员进行考核，考核结果作为聘任、晋级的重要条件。

第二十二条　切实做好实验室环境管理工作，对具有高温、辐射、病菌、毒性、粉尘等有害人体的环境要加强监督和控制，降低实验室噪音，合理排放废气、废水、废物。

第二十三条　按照《高等学校从事有害健康工种人员营养保健等级和标准的暂行规定》等文件精神，做好实验室工作人员的劳动保护工作。

第二十四条　遵守《西北农林科技大学教学实验室安全管理办法》，认真落实防火、防爆、防盗、防事故、防泄密等安全保密措施，经常对师生开展安全保密教育，切实保障人身和财产安全。

第二十五条　遵守国务院《化学危险品安全管理条例》和《西北农林科技大学化学危险物品安全监督管理规定》，对剧毒、易燃、易爆物资按规定进行保管使用，贵重、稀有物资要有严格的审批、领用、登记手续。

第二十六条　按照《高等学校仪器设备管理办法》、《西北农林科技大学仪器设备管理办法》、《高等学校材料、低值品、易耗品管理办法》做好实验室仪器设备、材料及低值易耗品等物资的管理，充分发挥仪器设备和材料的使用效益。

第二十七条　按照国务院《实验动物管理条例》、《植物检疫条例》和《病原微生物实验室生物安全管理条例》规定，对实验室所需的实验动物、植物及病原微生物进行管理、检疫和使用。

第二十八条　实验室对外出具公证数据，必须依照国家的有关规定，经上级计量部门认证后，方可出具。

第七章　人　员

第二十九条　实验室工作人员包括：从事实验室工作的教师、实验技术人员、管理人员和工人。

第三十条　实验室工作人员的编制，根据各实验室实验教学时数、总实验人时数、实验准备的难易程度、实验仪器设备状况和实验室总体工作量等，由学校主管部门依照相关编制管理办法核定。

第三十一条　实验室各类人员的聘任、晋职晋级工作，根据各实验室的特点和本人的工作业绩，按照国家和学校的有关规定执行。

第三十二条　实验室主任要由具有较高思想政治觉悟，有一定的专业理论修

养， 有实验教学、科研工作经验，组织管理能力较强的相应专业的副高以上技术职称的人员担任，由各院（系）推荐，学校正式发文。

第三十三条 实验室主任的主要职责是：

（一）负责编制本实验室建设规划和计划，并组织实施；

（二）负责本实验室的实验教学、研究以及建设和管理工作；

（三）负责制定本实验室各项规章制度，并组织实施；

（四）协助院（系）做好本实验室工作人员的管理、培训和考核；

（五）做好本实验室工作人员思想教育工作；

（六）定期检查、总结本实验室工作。

第三十四条 其他实验室工作人员的岗位职责，由各院（系）根据实验室的工作目标、任务，按照不同专业技术人员的工作职责及聘任考核规定具体确定。

第三十五条 实验室工作人员要有明确的职责分工，要遵守国家的法规、政策， 遵守学校的规章制度，各司其职，团结协作，积极完成各项任务。

第三十六条 实验室各类人员调离、退休时，必须按规定办理相应的移交手续， 各院（系）要根据需要，安排人员接替其工作。

第三十七条 实验室管理处定期开展实验室工作的检查、评比活动。对成绩显著的个人给予表彰奖励，对工作不负责任造成损失或违章失职者，分别给予批评教育或纪律处分。

第八章　附　则

第三十八条 各院（系）根据本办法，结合实验室实际，制定各项具体规定及实施细则。

第三十九条 本办法自发布之日起执行，原《西北农林科技大学教学实验室管理规程》同时废止。

第四十条 本办法由实验室管理处负责解释。

二〇〇五年六月二十四日

西北农林科技大学教学实验室开放管理暂行办法

校实验发〔2005〕270号

第一章　总　则

第一条　为鼓励和支持学生在课余时间参加开放式实验教学、科研和各类科技活动，进一步加强学生的实践技能，培养学生的创新意识和创新能力，规范、有序地做好我校教学实验室的开放工作，制定本办法。

第二条　全校教学实验室均要对学生开放，各开放实验室在不影响正常实验教学的情况下需为学生提供必要的实验场地、实验材料、仪器设备、实验技术支持、安全防护措施等，最大限度地发挥实验教学资源的效益。

第二章　实验室开放的管理

第三条　实验室开放时间一般为8：00－22：00，各实验室可根据实验内容来确定具体开放时间。

第四条　每学期开学初和寒暑假前，各实验室需将本学期及寒暑假期间的实验室开放时间、地点等向学生公布；实验室开放可采取定时开放和预约开放两种形式，　实行登记制，参加实验的学生需在相关实验室登记所学专业、班级、姓名、实验项目等信息。

第五条　进入开放实验室的程序：

1.参加实验的学生阅读有关文献资料，确定实验方案、技术路线、可行性分析、实验所需材料等内容。

2.学生填写《西北农林科技大学进入开放实验室申请表》，交由相关教研组或指导教师进行审核。

3．审核后的申请表送到相关实验室，由实验室主任根据实验室情况安排具体实验时间。

4.学生进入开放实验室，必须遵守实验室的各种规章制度，严格按照操作规程使用仪器设备，认真做好各种记录。

5.学生在实验完成后，应向实验室提交实验报告或论文等实验结果，实验室应及时总结和开展交流工作。

第六条　开放实验室实行轮班制，要配备一定数量的指导教师和实验室工作人员承担实验室开放工作，保证在开放期间内，实验室至少有一名指导教师和一

名实验室工作人员在场，负责实验材料、仪器设备的准备、调整与维护，解答学生实验过程的疑难问题，对所做实验进行认定，并认真做好开放情况记录。

第七条 学生在实验室做实验的过程中，指导教师和实验室工作人员应注意加强对学生基本素质、操作技能、创造性科学思维方法和严谨治学态度的培养，防止水电及实验材料的浪费，同时做好安全防护工作，确保实验室财物及参加实验人员的安全。

第八条 为弥补实验室工作人员不足，可建立研究生实验员制度，各学院可适当聘用有兴趣从事实验室管理、并具备熟练操作技能的研究生协助实验室工作人员， 学院承担相关费用。

第九条 按开放实验项目的类型、学时数、参加学生人数、难度系数等，由所在院（系）核算实验室工作人员的开放实验工作量和津贴，鼓励实验人员参加实验室开放工作。

第三章　奖　惩

第十条 参与科技创新活动的开放实验项目，获得省、部级以上奖励的集体和个人（包括学生、指导教师和实验室工作人员），学校根据有关规定予以奖励。

第十一条 实验室开放过程中，实验室工作人员、指导教师和参加实验的学生应认真负责，对于在实验过程中出现的水患、火灾以及设备损坏等问题须追究当事人责任，并给予相应的处罚。

第四章　附　则

第十二条 各院（系）、实验教学中心根据本办法制定本单位实验室开放实施细则。

第十三条 本办法由实验室管理处负责解释。

第十四条 本办法自公布之日起实施。

二〇〇五年六月二十四日

西北农林科技大学大型仪器设备管理办法

校实验发〔2005〕270号

第一章　总　则

第一条 为了加强我校大型仪器设备管理，提高大型仪器设备利用效率，保证教学和科研工作需要，根据教育部《高等学校仪器设备管理办法》和《西北农林科技大学仪器设备管理办法》，结合我校实际，制定本办法。

第二条 大型仪器设备建设规划和年度计划应根据学校学科发展，优先保证承担重大科研项目的重点实验室和教学必需的实验室，重点支持有突出研究工作基础、学术学科带头人、稳定研究队伍的单位。

第三条 大型仪器设备购置应遵循"统筹规划、合理配置、避免重复、专管共用"的原则，充分发挥仪器设备的投资效益。

第四条 大型仪器设备是指：

1.单价在人民币10万元（含）以上的仪器设备；

2.价值人民币10万元（含）以上的成套仪器设备；

3.单价不足人民币10万元，但属于国外引进、学校及上级有关部门明确规定的贵重、稀缺、精密仪器设备；

4.国家科技部颁发的23种大型精密仪器目录中的仪器设备。

第五条 大型仪器设备管理分两种方式：一是实验室管理处直接管理；二是学校委托院（系）或所代管。代管单位所管仪器设备应面向全校及社会开放，不得私自调拨，否则学校有权处罚或调出。

第二章　购置和验收

第六条 购置大型仪器设备应履行下列程序：

1.申购单位向实验室管理处提出申请,并在实验室管理处网站下载、填写《西北农林科技大学大型精密贵重仪器设备论证报告》。

2."西北农林科技大学大型、精密、贵重仪器设备联合评议工作组"对《论证报告》进行科学论证，论证通过后方可进入招标采购程序。

第七条 验收工作是保证仪器设备质量和正常运行的关键，应把握好下列环节：

1.建立由新购大型仪器设备负责人、操作人员、管理人员、国有资产管理处

和实验室管理处等组成的验收小组，按照学校有关仪器设备验收程序组织验收。

2. 大型仪器设备依托单位必须事先作好验收准备工作，包括阅读技术资料、制定验收方案等。必要时，提交仪器设备试运行报告。

3. 仪器设备到货后应按合同及时组织验收，验收的主要内容包括：仔细检查和记录外部包装的情况及设备表观的异常现象（如有无受潮、锈蚀、损伤等）；根据合同和装箱单，认真进行品种、数量及附件的核对验收，并写出验收报告。

4. 安装调试中，须严格按照合同条款及仪器设备的技术指标逐项验收仪器设备的功能，注意技术指标数据的重现性和稳定性，必要时连续运转，确保设备性能稳定、质量可靠。有关凭证和技术资料不全者，应拒绝验收。验收中，如发现错货、缺货、损坏等情况，要及时办理补退和索赔手续。

第八条 设备验收合格后的有关技术资料,包括申请购置的审批件、合同、装箱单、验收记录、验收登记表等，仪器负责人必须在一个月内将其整理成册，以原件形式交档案馆建立仪器设备档案。

第三章　使用和管理

第九条 大型仪器设备的所有权属于学校，实验室管理处代表学校行使管理权。

第十条 依托单位确定专人管理大型仪器设备。管理人员应思想作风正派、工作责任心强，能熟练掌握仪器操作技术，熟悉操作规程和注意事项，了解仪器一般故障的排除和处理方法，确保操作质量。

第十一条 及时建立仪器设备管理规章制度、安全操作规程；对使用、维修保养等做好详细登记记录，仪器必须由固定管理人员操作使用，其他人员应在管理人员指导下或经培训、考核合格后方可上机操作。

第十二条 大型仪器设备一般不许借出使用，确属特殊情况，需经院（系）领导和设备主管部门审批，并严格履行借还验收和交接手续。

第十三条 大型仪器设备一律不准自行拆改或解体使用，确有必要时，须经院（系）和学校主管部门批准后方可进行。

第十四条 大型仪器设备应充分、合理地利用原有功能，经有关专家分析、论证， 实验室管理处批准后，鼓励挖掘和开发新功能、新测试方法，使仪器设备发挥最大和最佳效益。

第四章　共享

第十五条　为了提高大型设备的利用率，要坚持"专管公用、资源共享"的原则，在完成教学与科研的同时，鼓励多种形式的开放服务，充分发挥其使用效益和社会效益。

第十六条　实验室管理处作为学校大型仪器设备共享的管理部门，负责制定有关办法及管理制度，建立运行考核指标体系，并组织实施、监督执行，协调解决实施过程中出现的问题。大型仪器所在单位的实验室主任，负责本单位仪器设备共享的组织实施工作。

第十七条　仪器所在实验室针对可共享仪器条件，制定具体的共享管理实施措施。

第十八条　非客观原因造成测试分析任务未按时完成和试剂样品浪费的，由技术操作人员及仪器所在单位负责。

第十九条　用户须遵守仪器所在单位的有关规定，服从技术操作人员的管理，未经许可不得随意动用实验室内的仪器设备，注意维护实验室内环境卫生和秩序。

第五章　维修和保养

第二十条　按照国家有关规定，对大型仪器设备应定期进行校验标定。

第二十一条　重视维修维护工作，禁止超负荷、超时限、超压使用，严格遵守安全操作规程。

第二十二条　针对其特点，做好防尘、防潮和控温、控湿工作，尽可能使用专用材料进行维修保养。

第二十三条　当仪器设备发生故障时，要及时登记事故现象，尽快修复，对较大事故，专管人员（或当事人）要及时详细提交事故报告，组织院（系、所）领导和有关专业人员分析事故原因，提出处理意见并报实验室管理处。

第六章　报损报废

第二十四条　已到报废期限，或确已失去使用价值的大型仪器设备，由国有资产管理处和实验室管理处组织有关人员做出技术鉴定，并按相关程序及时办理报废登记手续。

第二十五条　对于精度明显降低、型号落后，但仍可使用的大型设备，应按照上述手续进行降级使用或转为教学演示使用。

第七章　考核与奖惩

第二十六条 仪器设备共享工作根据《高等学校贵重仪器设备效益年度评价表》定期进行考核评比。考核评比的主要内容：

1. 开展资源共享的有效机时（实际测试时间+前、后处理时间）。

2. 完成的教学实验、科研课题 、成果数及人才培养数。

3. 贵重仪器功能利用和开发数。

4. 资源共享的规章制度是否健全以及落实情况。

5. 账目管理及日常维护管理情况。

第二十七条 考评工作的组织机构是实验室管理处。考评工作每年进行一次。

第二十八条 在仪器所在单位认真自查自评的基础上，实验室管理处组织有关专家进行评审，并签署评价意见。

第二十九条 学校根据考评结果，对在专管共用、功能开发等方面成绩突出的， 将予以表彰和奖励，并作为考核晋级的依据；对使用效益差、保养不良、管理不善或造成失职行为者，将视情节轻重进行处罚，必要时实验室管理处和国有资产管理处有权将该设备调拨到迫切需要、管理规范的单位。

第八章　附 则

第三十条 本办法自发布之日起执行。

第三十一条 本办法由实验室管理处负责解释。

二〇〇五年六月二十四日

西北农林科技大学教学仪器设备维修管理办法

校实验发〔2006〕303号

第一章 总 则

第一条 为了加强我校教学仪器设备维修管理，提高完好率，充分发挥仪器设备的使用效益，保障教学工作的正常运行，根据教育部《高等学校仪器设备管理办法》和《高等学校实验室工作规程》等有关规定，结合学校实际，制定本办法。

第二条 教学仪器设备维修本着"保证教学，服务科研"的原则，实行归口管理、分级负责，由实验室管理处具体组织实施。

第三条 仪器设备使用单位职责

1.根据实验教学情况，制定本单位仪器设备维护、保养与维修管理制度。

2.做好仪器设备日常维修和维护保养，保证仪器设备经常处于良好的技术性能状态。对大型精密贵重仪器应精心维护，定期进行检测、检修，并做好维护、检测、检修记录。

3.仪器设备需要维修时，应及时进行维修；本单位不能维修的应及时报修，以保障正常的教学秩序。

第四条 学校每年按教学仪器设备总值的 1—2%设立教学仪器设备维修基金，专款专用。

第二章 维修范围及原则

第五条 教学和教学科研共享仪器设备属正常磨损、损坏的，学校保证维修经费。

第六条 科研仪器设备维修费用由项目经费自理，学校提供必要的支持和协助。

第七条 属违反操作规程等人为因素损坏或丢失零配件等，按《西北农林科技大学仪器设备损坏丢失赔偿实施细则》执行。

第八条 仪器设备在保修期内出现故障，仪器设备使用单位直接或通过国有资产管理处与厂方联系，由厂方或供货方维修。

第九条 保修期内未及时开封、安装、调试、验收的仪器设备，出现故障，或验收时存在问题而未及时解决的，由仪器设备使用单位与供货商或厂家协商解

决。

第十条 对于已到寿命周期年限、无修复价值或维修费用超过原值 50%的仪器设备，原则上应予以报废，不再修理。

第十一条 对于大型精密贵重仪器设备维修的审定，学校将以仪器设备使用原始记录为准，没有使用记录的，将被认定为未使用，原则上不予立项维修，不承担相关费用。

第三章 维修程序

第十二条 教学仪器设备维修程序

1.教学仪器设备需要维修时，仪器设备管理人员与实验室管理处进行电话预约，实验室管理处及时组织人员安排维修。

2.维修人员接到报修电话后，应在一个工作日内对报修仪器进行检修，并填写《西北农林科技大学仪器设备维修单》；一般故障应在二到三个工作日内修复，特殊故障应向报修单位实验员说明情况，提出解决方案和修复时间。

3.仪器设备维修结束后，由实验室管理处和使用单位、维修方共同验收，并在《西北农林科技大学科教仪器设备维修单》签字认可。

4.设备维修实行保修制度，其保修期原则上定为半年；维修费用超过 1000 元的， 使用单位与维修方签订维修质保协议，保证维修质量。

5.仪器设备需要送外维修时，维修人员需签署意见，实验室管理处审批同意后， 由使用单位送外维修或联系校外技术人员来校维修。

第四章 维修保障

第十三条 为保障实验教学的正常运行，建立以仪器设备管理人员、实验室管理处维修人员为主，仪器公司售后服务和社会专业维修公司为辅的仪器设备维修保障体系。大型精密贵重仪器设备由实验室管理处根据情况会同生产厂家或联系有关专家进行维修。

第十四条 教学仪器设备使用单位应建立仪器设备技术档案，并由专人负责保管。技术资料档案应包含以下内容：

1.购置仪器设备的论证资料。

2.仪器设备验收资料，包括产品合格证、使用说明书、线路图和保修证等。

3.使用人填写的"西北农林科技大学仪器设备维修记录"，包括仪器设备的检修、保养、维护、日常使用等情况。

第五章 奖 惩

第十五条 各单位仪器管理人员对出现故障的仪器设备应及时进行维护、保养和报修。对仪器设备利用率高、维修及时、自修率高、完好率超过 95％、综合效益好的单位和个人，给予表彰和奖励，并作为对实验室和仪器设备管理人员考核的重要依据之一。

第十六条 对仪器设备维修不及时、维护不到位、完好率差的单位和个人，依学校有关规定予以批评或处罚。

第六章 其 它

第十七条 本办法自颁布之日起施行。

第十八条 本办法由实验室管理处负责解释。

二〇〇六年十一月二十八日

西北农林科技大学大型精密贵重仪器设备共享办法

校实验发〔2006〕303号

第一章 总 则

第一条 为了加强我校大型精密贵重仪器设备（以下简称大型设备）管理，提高大型设备利用率和投资效益，根据教育部《高等学校仪器设备管理办法》和《西北农林科技大学大型仪器设备管理办法》，制订本办法。

第二条 凡《西北农林科技大学大型仪器设备管理办法》规定的仪器设备，均属国有资产，必须纳入共享范围，充分挖掘大型设备资源潜力，实现资源共享，充分发挥其在教学、科研和社会服务中的作用。

第二章 管理与运行

第三条 学校大型设备资源共享的主管部门是实验室管理处。负责制定有关管理办法及规章制度；制定运行考核指标体系，并组织实施和监督本办法的执行；协调、解决实施过程中出现的问题；负责收集、整理和发布大型设备共享信息。

大型设备依托单位的实验室主任负责本单位仪器设备资源共享的组织实施工作。按照有关要求及时提交本单位大型设备共享申请和大型设备有关共享信息。在申购 大型设备的同时，必须与学校主管部门签订大型设备共享协议，并按要求在设备安 装调试完毕后 15 个工作日内提交大型设备共享信息。

第四条 大型设备资源共享运行

1. 学校建设大型设备资源数据库与网络信息平台，利用大型设备共享信息平台实现信息查询和共享的网上预约。

2. 所有大型设备均实行有偿使用。

第五条 依托单位应为大型设备配备相对稳定的操作技术人员，以保证共享大型设备的正常运行和服务质量。如人员变动由实验室主任负责监督办理交接手续。

第六条 设备管理人员职责

1. 所有操作技术人员必须经过有关部门严格的业务培训并取得相应的资质，方可持证上岗。

2. 遵守有关保密规定，责任心强，熟悉大型设备的结构和工作原理，掌握其操作规程和注意事项，了解大型设备一般故障的排除和处理方法。

3.定期做好大型设备的维护和保养工作,使大型设备经常处于良好的工作状态, 出现问题及时处理并向实验室主任汇报。

4.热情为用户服务,及时安排和完成用户提交的分析测试任务;按时为具备大型设备操作资质的用户提供上机服务。

5.如实填写仪器使用记录,同时按要求填写实验项目名称、使用机时、使用耗材、试剂种类和数量、应收取的实际费用等。

6.及时编制所需耗材的购置计划。

7.保持大型设备工作环境整洁有序,严格遵守有关管理规章制度。

第七条 用户义务

1.用户根据分析测试要求,应在开机前 3-5 天向大型设备所在单位提出预约申请,并说明所做实验的的特殊要求、所需条件等,以保证大型设备按时开启使用。

2.用户预约后,应及时送样分析。因用户方面造成未能按时分析测试以及试剂、材料等浪费的,由用户负责。

3.具备大型设备操作资质的用户可以持证并在管理人员的指导下上机开展有关工作。

4.用户必须遵守大型设备所在单位的有关规定,服从大型设备管理人员的管理, 维护实验室内环境卫生和秩序。

5.分析测试完成后,及时办理有关手续、结清帐务。

第三章　收费与管理

第八条 为了保证大型设备的正常运行与维护,对使用大型设备的单位和个人收取一定的费用。

第九条 收费内容及标准

1.收费内容包括:设备折旧费、材料消耗费、技术服务费、水电费和管理费等。校内送检和自主操作收费包括:材料消耗费、技术服务费、水电费和管理费等。校外送检收费包括:设备折旧费、材料消耗费、技术服务费、水电费和管理费等。

2.参照陕西省大型仪器设备协作共用网及兄弟院校等的收费标准结合学校实际, 由实验室管理处牵头,会同各依托单位制定全校统一收费标准。

第十条 收费方式

校外测试分析费用以现金或支票方式支付,校内实行内部转帐支付。

第十一条 共享收益分配

1.大型设备共享收益主要来源于对外（校外）服务收入。

2.共享收益分配的原则是：兼顾学校、依托单位及机组人员的利益，充分调动各方面的积极性，促进大型设备的有效共享。

3.分配比例：大型设备共享收益扣除材料消耗费、技术服务费及水电费等成本后按 10％作为管理费上交学校；按照购置经费来源不同，分别依照不同比例留大型设备依托单位，由依托单位安排使用，用于大型设备共享的业务费、材料费、设备维护费及机组人员补助等。其中学校投资购置的大型设备按照 60％的比例留大型设备依托单位，由科研经费购置的大型设备按照 80％的比例留大型设备依托单位；剩余部分用于补充大型设备的共享基金和维修基金；

第四章　共享基金的设立与管理

第十二条 大型设备共享基金的设立

学校每年从设备费中预留 5％（每年不少于 100 万元）设专户作为大型设备共享基金。

第十三条 共享基金管理

1.学校成立大型设备共享基金管理领导小组,负责审批基金资助,评估基金使用等重大事宜。实验室管理处负责基金的申报、评定、统计及日常工作。

2.共享基金主要用于校内人员分析测试费用补助、设备维修维护、零配件购置、新功能开发及对操作技术人员进行业务培训与奖励等。

第十四条 共享基金使用效益考核

凡获得基金项目资助的单位，年终须提交基金使用总结报告。由大型设备共享基金管理领导小组对基金使用情况进行评估。

第五章　考评与奖惩

第十五条 大型设备考评的基本原则是"考评促管，管理促效，"通过考核评比，进一步挖掘大型设备的潜力，提高大型设备利用率和投资效益。

第十六条 大型设备资源共享工作根据《高等学校贵重仪器设备效益年度评价表》定期进行考核评比，考核评比的主要内容：

1.开展资源共享的有效机时（实际测试时间+前、后处理时间）。

2.完成的教学实验、科研课题、成果数及人才培养数。

3.功能利用和新项目开发数。

4. 资源共享的规章制度是否健全及落实情况。

5. 帐目管理及日常维护管理情况。

第十七条 大型设备的考评工作由实验室管理处组织实施。考评工作每年进行一次，评出资源共享工作的先进实验室和先进个人。

第十八条 考评工作的程序

1. 大型设备依托单位认真总结共享工作经验，组织自查自评。

2. 实验室管理处组织有关专家进行互查、互评。

3. 实验室管理处对考评工作进行评审，并签署评价意见。

第十九条 奖惩

1. 对共享效果好、开放服务有效、考核优秀、基金使用合理的机组和个人，学校给予物质和精神奖励。

2. 对于通用设备年使用机时在 1400 小时（其中共享机时 560 小时）以上，专用设备年使用机时在 800 小时（其中共享机时 320 小时）以上者由学校全额提供维修费；通用设备年使用机时在 800 小时（其中共享机时 400 小时）以上，专用设备年使用机时在 400 小时（其中共享机时 200 小时）以上者学校提供 70％的维修费。通用设备年使用机时在 800 小时（其中共享机时 400 小时）以下，专用设备年使用机时在 400 小时（其中共享机时 200 小时）以下者，其维修费用由依托单位自理。

3. 对因服务态度、工作质量、技术水平等主观因素影响大型设备共享工作开展的有关人员，进行批评和帮助；对不能及时改进的，应进行人员调整；对确因责任心不强造成仪器损坏、丢失和分析失败的按有关规定处理。

4. 对有条件而不能及时开展资源共享工作，大型设备使用率又低于 200 小时／年的单位和实验室，视情况按下述相关条款执行：

（1）找出原因，制定整改计划，限期改进。

（2）减拨或停拨有关费用。

（3）大型设备所在实验室、实验室主任及有关操作技术人员不能进入当年的先进评选。

（4）本单位闲置不用又未能投入资源共享的大型设备，按规定收取大型设备占用费或调拨给学校其它部门管理和使用。

第六章　附则

第二十条　依托单位针对本室共享大型设备特点，制定具体管理实施细则。

第二十一条　本办法自公布之日起执行。

第二十二条　本办法由实验室管理处负责解释。

二〇〇六年十一月二十八日

西北农林科技大学教学实验室年度考核评价试行办法

实发〔2007〕04号

为加强我校教学实验室建设和管理，促进实验室开放与共享，推动实验教学改革与创新，根据《西北农林科技大学教学实验室管理办法》和《西北农林科技大学教学实验室评估办法》，结合学校实际,特制定本办法。

一、考核评价目的

通过考核评价，建立"安全、规范、高效、开放"的实验室管理工作体系，使实验室更好的为教学、科研和生产服务。

二、考核评价范围与时间

范围：学校正式批准建制的教学实验室时间：每年度进行一次考核。

三、考核评价内容

考核评价内容包括：实验室运行管理、环境安全、实验教学、实验队伍、创新与成效等，考核评价指标体系详见《西北农林科技大学教学实验室年度考核评价表》。

四、考核评价程序

（一）各学院根据考核要求进行组织，以实验室为单位进行自评；

（二）实验室管理处组织相关人员成立考核评价工作小组，进入实验室进行实地考核，通过查、看、问等形式进行综合打分。

五、结果与奖惩

（一）依据考核评价结果，对评分较高的实验室予以表彰，对评分较低的实验室提出整改意见。

（二）考核评价结果作为运行管理相关费用补贴的依据；

六、其他事项

1.本办法自公布之日起执行。

2.本办法由实验室管理处负责解释。

二〇〇七年十二月十九日

附件：西北农林科技大学教学实验室年度考核评价表

20 ～20 学年 年 月 日

实验室名称：	地址：	所在院（系）：			
考核评价指标		考核评价内容和方式	分值	评分	
一级指标	二级指标			自评	校评
运行管理	实验室档案	随机抽查实验室档案，包含相关文件、人员信息、运行记录等，非常完整、规范，且采取数据库管理，得5分；较好3分；不合格，不得分。	5分		
	规章制度	各种管理制度，包含人员岗位职责及考核办法等齐全，得5分；较好3分；不合格，不得分。	5分		
	设备完好率	随机抽查5台设备，运转正常，得5分；不正常或未及时报修，每台扣1分，扣完为止。	5分		
	实验室利用率	按照公式：实验室利用率＝（实验室实际工作量/实验室额定工作量）×100％，其中实验室额定工作量，公共基础课69120 人时数，专业基础课38400人时数，专业课19200人时数。利用率100%，得20分，每降一个百分点，扣0.4分，扣完为止。	20分		
	工作着装	人员着工作服、佩戴上岗证，2分；一项不符，扣1分。	2分		
环境安全	环境卫生	物品摆放整齐，无杂物、灰尘、蛛网、垃圾等， 废弃物处理符合有关规定，得5分；一般，3分；较差，0分。	5分		
	安全保护	化学危险品、防火、环境设施、水电等符合有关规定，得5分；部分符合3分；完全不符合，0分。	5分		
实验教学	实验开出率	依据教学大纲，按照公式：实验开出率＝（实开实验/应开实验）×100 ％，实验开出率100%，得 20分，每降一个百分点，扣2分，扣完为止。	20分		
实验队伍	数量和结构	专职人员3人以上，且高级技术职务人员比例≥20%，得5分；有专职人员，但高级	5分		

		技术职务人员比例＜20%，3分；两项均不符，不得分。			
	培 训与提高	培训计划与记录资料完整规范，得5分；计划或记录不齐全，3分；无计划、无记录，不得分。	5分		
创新与成效	实验室开 放	有相关开放实施细则，得2分；无，不加分。	2分		
		学院有实验室开放专项经费与使用办法 5分；有经费使用办法，无经费支持，3分；无办法，无经费，不得分。	5分		
		学院有实验室开放收入分配办法并实施，得5分；有收入分配办法，未实施，3分；无办法，不得分。	5分		
	成 果与研发	主持国家及省部级教改项目或取得成果 1项加2分；主持校级教改项目或取得成果1项加1分；核心期刊发表论文1篇加2分；一般公开刊物发表论文1篇，加1分，最高不超过6分。	6分		
		仪器设备功能开发、自制或改装设备、开发实验教学软件，并应用于实验教学，1项加1分；最高不超过5分。	5分		
合计			100分		

西北农林科技大学大型精密贵重仪器设备年度考核评价试行办法

实发〔2007〕04号

为了强化我校大型精密贵重仪器设备（以下简称大型设备）的科学管理，进一步提高大型设备资源的开放与共享，根据《西北农林科技大学大型仪器设备管理办法》和《西北农林科技大学大型精密贵重仪器设备共享办法》，结合学校实际，特制定本办法。

一、考核评价原则和目的

坚持"实事求是，客观公正"的原则，不断提高学校大型设备的使用效率，使其在学校教学、科研工作发挥更大作用。

二、考核评价对象 www.TT91.com

（一）单价在人民币10万元（含）以上的仪器设备；

（二）价值人民币10万元（含）以上的成套仪器设备；

（三）单价不足人民币10万元，但属于国外引进、学校及上级有关部门明确规定的贵重、稀缺、精密仪器设备；

（四）国家科技部公布的23种大型设备。

三、考核评价内容

主要内容由机时利用、人才培养、科研成果、服务收入、功能利用与开发、管理规范、安全与环境等内容组成，各项目的评价以原始记录或证明材料为主要依据。考核指标体系详见附件。

四、考核评价等级

考核评价结果等级划分为优秀、良好、合格及不合格四个等级。

优秀： 总分≥85分

良好： 70分≤总分<85分

合格： 60分≤总分<70分

不合格：总分＜60分

五、考核评价程序

（一）自评

学院（系、中心、所）成立自评考核工作小组，负责本单位大型设备评价考核工作。

1. 大型设备管理人员依据有关规定和要求，填写《大型精密贵重仪器设备年度考核评价表》；

2. 自评考核工作小组对表中填写的各项数据，进行逐台逐项核实、评分；

3. 根据评价标准和等级评出优秀、良好、合格和不合格四类大型设备；

4. 各单位根据自评结果形成总结报告，并对存在问题提出整改意见和措施；

5. 将自评考核评价表、总结报告等材料报实验室管理处，作为学校考核评价的依据。

（二）校评

实验室管理处负责全校大型仪器设备的评价考核工作。

1. 实验室管理处组织有关专家5－6人，采取查、看、听等方式，对学院（系、中心、所）大型设备进行实地评价考核；

2. 单价 40 万元以上设备为必查设备，对单价小于40万元的大型设备进行抽查，抽查数量不少于本单位大型设备总数量的20%；

3. 年度大型设备考核评价，单位自评与学校评价相结合，进行统计汇总并排序。

六、结果与奖惩

1. 考核结果作为学校分配大型设备购置费、运行维护费的重要依据。

2. 对考核结果优秀或取得突出成绩的部门及负责人，给予表彰奖励。考核结果不合格的大型设备，限期整改，整改后仍不合格的，将对其设备进行重新调配。

七、其他事项

1. 本办法自公布之日起执行。

2. 本办法由实验室管理处负责解释。

二〇〇七年十二月十九日

西北农林科技大学大型精密贵重仪器设备年度考核评价表

（   /   学年）

学院：   实验室：   设备编号：   设备名称：

序号	项目	权重	项目内容	数量	满分	评分标准及方法	分项得分	小计	分项加权得分	总得分
1	机时利用	30%	有效机时		100	（有效机时/定额机时）×100%				
			定额机时							
2	人才培养	20%	获得独立操作资格人员数		100	10分/人				
			指导下独立完成部分测试人员数			3分/人				
			进行教学演示实验人员数			1分/30 人				
3	科研成果	25%	国家、国际奖		100	80分/项				
			省部二等奖及以上			60分/项				
			校二等奖及以上			20分/项				
			核心刊物及以上级别论文			5分/篇				
4	服务收入	10%	校内外服务收入（千元）		100	5分/千元				
5	功能利用与开发	5%	功能利用数 a		100	a/b×100%	100%　60分 ≥80%　48 分 ≥60%　36 分 ≥40%　24 分 ≥20%　12 分 ＜20%　0 分			
			原有功能数 b							

			新增加功能数		10分/项				
6	管理规范	5%	操作规范		设备专人管理，操作规范上墙，30分	100			
			档案记录		技术档案与各项记录齐全，35分				
			维修保养		仪器设备维护保养、维修符合要求，35分				
7	安全环境	5%	安全措施		防火、防盗、防破坏防爆炸的设施与措施，废气、废液、废渣处理等符合有关要求，60分	100			
			环境卫生		环境整洁，通风、照明、温湿度等符合有关规定，40分				

填表说明：

一、表中各项目的"小计"得分最高不超过 100 分，未达到 100 分的按实际得分填写。

二、分项加权得分＝小计×权重。总得分＝分项加权得分之和。

三、数据填写

(一)机时利用

1、定额机时

03类仪器仪表：

通用设备：1400 小时/年　公式=7 小时×5 天×40 周=1400 小时

专用设备：800 小时/年　　公式=4 小时×5 天×40 周=800 小时

04类机械设备：800 小时/年　公式=4 小时×5 天×40 周=800 小时

2、有效机时：必要的开机准备时间+测试时间+必须的后处理时间

(二)人才培养

1、获得独立操作资格人员数指通过各种培训取得独立操作证书，并经主管

部门承认具有独立操作资格的人员数。

2、指导下能完成部分测试的人员数指在仪器设备工作人员指导下能独立完成部分测试项目的人员数。

(三)科研成果

各类奖中包括同级别的奖项、同级别发明及已授予的专利。

(四)服务收入

服务收入系指对校内、外服务的测试费，不包括本机组的科研费收入。

(五)功能利用与开发

1、原功能数系指大型设备本身原有的功能数。

2、新增加功能指自行研制开发，档次升级、技术改造及引进的软件功能等。

3、功能利用数指大型设备原有功能中被利用的数量。

四、数据审核

有效机时数	查使用记录
定额机时数	查本说明四(一)1
获得独立操作资格人员数	查有关证件或考核审批记录
在指导下能独立完成部分测试人员数	查使用记录及操作人员名单
教学演示实验人员数	查演示实验记录
国家、国际奖、省、部级奖、校级奖	查本年度获奖证书
论文	核查本年度相关刊物
校内外服务收入	查本年度财务收入证明等
原有功能利用数	查实验内容记录
原有功能数	查大型设备说明书或有关技术资料
本学年新增加功能数	查阅本学年新增加实验或测试项目记录

西北农林科技大学大型实验室用电安全管理规定

校实验发〔2008〕141号

第一章 总 则

第一条 为了加强实验室用电安全管理，确保学校教学科研工作正常秩序，根据《西北农林科技大学防火安全条例》、《西北农林科技大学实验室安全管理办法》、《西北农林科技大学防火安全检查规定》等文件精神，制定本规定。

第二条 本规定适用于我校和依托我校管理的所有教学科研实验室。

第二章 管理职责

第三条 实验室用电坚持"安全第一，预防为主"和"谁主管，谁负责"的原则，做好用电安全防范工作。

第四条 各学院（系、所、中心）作为实验室用电安全的直接管理和实施单位， 负责落实本单位实验室的用电安全措施。

单位行政主要领导为本单位实验室用电安全的第一责任人，实验室主任为管辖实验室的用电安全责任人，实验室工作人员为本实验室用电安全的直接责任人。

第五条 保卫处作为防火安全工作监督管理部门，负责实验室安全抽查、督促整改及消防器材的配备、维修和更新工作。

第六条 后勤管理处负责实验室电源的维护、维修与改造，并对实验室电路进线总负荷进行检测和标示。

第七条 实验室管理处负责制订全校实验室安全用电管理办法，督促、协助各学院（系、所、中心）建立健全用电安全制度和操作规程，负责实验室内电源认证的组织和实施。

第三章 电源认证

第八条 为了使实验室用电安全由事后治理转向事前预防与控制，消除安全隐患，实验室电源必须进行统一认证。

第九条 电源认证的主要内容：

1、制作、安装实验室用电安全责任人标示牌。

2、对实验室电源插座的负荷进行检测，区分插座类型，同时根据进线总负荷计算、制订每个插座的安全使用参数。

3、设计、制作、安装安全用电标示牌及警示牌等，对每一个电源和插座进

行标示。

第十条 标示牌分为使用标志、警示标志、提示标志等。

1、使用标志安装在电源插座上方，每个插座安装一个，标示内容为最大电压、电流、功率及待修停用等。

2、警示标志根据实验室仪器设备使用情况进行张贴，主要包括高压危险、禁止超荷运行等。

3、提示标志每个实验室张贴一套，内容主要包括节约用电、随手关灯、注意电源、人走断电、禁止私拉乱接电线等。

第四章 电源管理

第十一条 实验室需增加插座或改造线路，学院(系、所、中心)提出书面申请报实验室管理处，实验室管理处对其必要性进行审核，同意后由后勤管理处根据实验室内外的电路负荷及线路状况进行增加或改造。新增加的插座须经实验室管理处进行认证和标示后方可投入使用。

第十二条 实验室电路及电源插座等需维修的，学院（系、所、中心）报后勤管理处，由后勤管理处负责维修。

第十三条 因工作需要，实验室内须搭建临时用电线路时，学院(系、所、中心) 提出书面申请报实验室管理处，实验室管理处审核同意后，由后勤管理处负责搭建， 用完后及时予以拆除。

第十四条 实验室尽量少用或不用插线板，如要使用，所用插线板必须经过实验室管理处认证标示后方可使用。

1、大功率（2KW 以上）及连续使用超过半个工作日以上的仪器设备严禁使用插线板。

2、使用插线板必须有专人负责，用后及时切断电源。

3、插线板必须独立使用，严禁插线板串接使用。

4、插线板及其线路周围 30 厘米内严禁堆放物品，确保散热畅通。

5、使用插线板的仪器设备的功率必须小于插线板的负荷。

6、插线板所承载的仪器设备的功率必须小于所连插座的负荷。

第十五条 使用白炽灯、高压汞灯照明或加温时，灯与可燃物之间的距离不小于 50cm，严禁用纸、布等可燃材料遮挡灯具。

第十六条 100W 以上的白炽灯、卤钨灯的灯管附近导线应采用非燃材料制

成的护套保护，以免高温破坏绝缘，引起短路。灯的下方严禁堆放可燃物品。

第五章　罚　则

第十七条　学校定期组织相关部门对各单位实验室的用电安全进行检查、评比，检查不合格的，限期整改，整改不合格的，通报批评，并追究单位负责人的责任。

第十八条　违反本规定，造成火灾事故或重大安全事故的，追究责任人和当事人的责任；触犯法律的，移交司法机关处理。

第六章　附　则

第十九条　本规定自下发之日起实施，由实验室管理处负责解释。

西北农林科技大学关于加强大型仪器设备共享平台建设的意见

校实验发〔2009〕69号

近几年来，随着学校事业的快速发展，我校大型仪器设备拥有量大幅增加，其中单台价值 10 万元以上的仪器设备数量由 2003 年底 252 台，总值 0.58 亿元，到 2008年上升到 475 台，总值 1.30 亿元。五年中数量和总值分别增加 1.88 倍和 2.24 倍。大型仪器设备的添置，对培养高层次人才，开展科技创新，无疑起到了重要作用。但是，我校大型仪器设备大幅增加与设备使用率低下的问题不容忽视。

为进一步加强学科建设，整合优质资源，探索建立适合校情的大型仪器设备管理机制，提高大型仪器设备投资效益，特提出如下意见：

一、统一思想，明确共享平台建设的意义与作用

大型仪器设备共享平台建设是将单价 10 万元以上、通用性强、服务面宽的仪器设备以学院(重点实验室、工程研究中心)为管理单位,相对集中,专管共用。

我校大型仪器设备使用率低下的原因尽管是多方面的，但重复购置、分散管理、信息封闭、高水平实验技术人才缺乏、科研项目少等是主要原因所在。建立大型仪器设备共享平台，有利于打破传统的封闭格局，实现开放共享；有利于合理分配资源，提高使用效益；有利于集中有限的人、财、物购买急需的大型仪器设备，更好地为学科建设、科技创新、高层次人才培养服务。

为此,全校师生应站在全面落实科学发展观,建设高水平研究型大学的高度,统一思想，大力支持，积极推进我校大型仪器设备共享平台建设与发展。

二、大型仪器设备共享平台建设的目标与原则

学校统一规划，以学科为依托，以学院(重点实验室、工程中心)为主体，以效益为核心，对通用性强的大型仪器设备相对集中，建立校、院（重点实验室、工程研究中心）两级大型仪器设备开放共享平台，配备相适应的技术管理人员，面向校内外开放服务，实行大型仪器设备"专管共用，资源共享"。

（一）总体目标：

在近 1-2 年内，建成 1 个校级大型仪器设备共享平台，并选择 5-6 个有一定基础的学院(重点实验室、工程研究中心)，积极探索符合实际的共享平台管

理体制与运行机制，初步形成资源共享、专管共用的共享平台。

今后 3-5 年，建成通过国家计量认证的校级分析测试开放服务平台；建立健全由学院(重点实验室、工程研究中心)集中管理、专管共用的制度与机制，稳定技术队伍、保障运行经费，形成布局合理、功能齐全、开放高效的校、院两级管理的共享平台。

（二）基本原则

1.依托学科、相对集中。以学科为依托，以学院（重点实验室、工程研究中心）为基础，将大型仪器设备相对集中，实行设备、人员、经费统筹安排。

2.创造条件，开放共享。利用网络技术，建立仪器设备信息平台，配备与开放共享体系相适应的实验技术和管理人员，保障信息畅通，准确、高效开放。

3.统筹规划，分期建设。大型仪器设备共享平台建设应统筹规划，逐步创造条件，通过政策引导、择优扶持、考核评价等措施，分期建设和逐个验收。

三、大型仪器设备共享平台建设的要求与内容

校级平台与院级平台分级管理、空间布局和仪器设备相对集中、设备管理和设备操作专人负责、设备资源和测试分析有偿使用、科学定价和服务收入合理分配。

1.以科研主楼的生物技术平台为基础，将通用性强的"高、精、尖"大型仪器设备(单价 40 万元及以上)相对集中,建立面向校内外开放服务的校级大型仪器设备共享平台，实行设备、人员、经费由学校统筹管理。

2.建立若干学院（重点实验室、工程研究中心)共享平台。根据学科特点和需求，以学院（重点实验室、工程研究中心）平台为主建立共享平台，将单价 10 万元及以上大型仪器设备相对集中,统筹运行经费,配备专(兼)职技术管理人员,面向校内外开放服务。

3.学院应促进学科整合和融合，加强省部级重点实验室建设，大型仪器设备共享平台应当围绕省部重点实验室进行建设。

4.建立大型仪器设备信息发布、预约申请、通知确认、收费补贴、考核评价等一系列可操作、可量化、可考核的有偿使用管理机制；通过大型仪器设备开放共享管理信息系统，实现大型仪器设备的动态管理。

5.结合我校实际，尽快出台相关配套政策及措施，确保共享平台科学管理，

高效运转，取得实效。

四、大型仪器设备共享平台建设的保障措施

1.加强组织领导。成立学校大型仪器设备管理委员会，审议共享平台建设计划和大型仪器设备购置论证材料，优化和调控大型仪器设备的配置；审议学校大型仪器设备共享基金项目；评选优秀机组和先进个人，协调共享平台重要事宜。学校大型仪器设备管理委员会由主管校长任主任，成员由教务处、科研处、人事处、计财处、研究生院、学科建设办公室、国有资产处、实验室管理处等部门负责人和仪器设备使用管理专家组成。大型仪器设备管理委员会日常工作由实验室管理处负责。

2.加强投入导向与使用管理，建立以大型仪器设备共享为导向的投资机制。今后国家设备专项和学校的设备配套经费等，应加大投入校、院两级共享平台建设力度。

3.学校建立大型仪器设备共享基金，纳入学校财务预算，具体额度根据实际情况确定，专款用于大型仪器设备共享平台内的实验项目测试、实验技术人员培训、新功能开发等补贴。学校对大型仪器设备共享平台用房面积给予补助。

4.加强共享平台骨干技术队伍建设。要将大型仪器设备共享平台建设与骨干技术队伍建设有机结合，设立大型仪器设备实验技术与管理岗位；根据学校、学院共享平台仪器设备的数量和工作任务，配备素质较高的专(兼)职实验技术与管理人员。共享平台可实行固定编制与流动编制相结合，实行岗位责任制与年度考核制。鼓励科教人员积极参与大型仪器设备的管理、操作与新功能开发，并计入一定的工作量。

5.加强共享平台的绩效考核与奖优罚劣工作。学校大型仪器设备管理委员会每年定期对共享平台运行管理和效益状况进行检查与考核，考核结果分为优秀、良好、合格、不合格。考核结果要在校内公布，并作为今后学校设备购置经费投入的依据。考核优秀并取得突出成绩者，学校对仪器设备所在单位和机组人员予以表彰奖励；不合格者，仪器设备所在单位应及时找出原因，限期整改；考核评价连续二年不合格的仪器设备，学校将调拨给校内其它部门管理和使用。

二〇〇九年三月十七日

西北农林科技大学大型仪器设备有偿使用管理暂行办法

校实验发〔2009〕70号

第一章 总则

第一条 为提高我校大型仪器设备使用效率和投资效益，科学配置资源，推进开放共享，依据教育部《高等学校仪器设备管理办法》和《西北农林科技大学大型仪器设备管理办法》，结合我校实际，特制定本办法。

第二条 凡我校单价在 10 万元以上的大型仪器设备，通用性强且设备状态良好， 经学校审定公布，实行有偿使用。

第二章 组织管理

第三条 学校成立由主管校长任组长、相关单位负责人和专家为成员的大型仪器设备管理委员会（简称管理委员会）负责统筹和协调大型仪器设备管理工作；实验室管理处作为大型仪器设备运行管理主管部门，负责全校大型仪器设备有偿使用的组织实施工作；仪器设备所在单位成立相应的有偿使用领导小组，负责本单位大型仪器设备有偿使用的日常管理工作。

第四条 学校统一规划，建立校、院两级大型仪器设备共享平台，实行大型仪器设备"专管共用，资源共享"；通过培训、引进等切实有效的措施，建立一支相对稳定且技术操作熟练的专业化实验技术骨干队伍，为全校师生提供高质量和高水平的服务。

第五条 建立大型仪器设备信息发布、预约申请、通知确认、收费补贴、考核评价等一系列可操作、可量化、可考核的有偿使用管理机制；通过大型仪器设备共享管理信息系统，实现大型仪器设备的动态管理。

第三章 收费管理

第六条 大型仪器设备使用实行有偿服务、科学定价、统一收费、合理分配，鼓励大型仪器设备主动对外服务，逐步实现以机养机。

第七条 大型仪器设备服务收费标准分为校外价格和校内价格两种。面向社会服务按校外价格收取，面向校内师生服务按校内价格收取。

第八条 收费标准

校外价格：国家主管部门有统一定价的，执行国家标准。没有统一定价的，

参照市场价格或以下要素制定：

  （一） 设备折旧费：设备值÷折旧年限÷年额定机时数；

  （二） 水、电、气、房屋占用费；

  （三） 实验耗材费；

  （四） 人工费：按照现行工资水平计算；

  （五） 微额利润（不超过以上成本的 10%）。

校内价格：按校外价格的 50%收取，或参照以下要素制定：

  （一）水、电、气、房屋占用费；

  （二）实验耗材费；

  （三）人工费：按照现行工资水平的 50%计算；

  （四）维修费：设备值×6%÷年额定机时数。

第九条 收费标准的审定程序：由仪器设备所在单位核算运行成本，结合市场调研，拟定收费标准，填写《西北农林科技大学大型仪器设备服务收费标准申请表》，报实验室管理处审核备案后公布。

第十条 收入分配

（一）50%用于设备日常运行费，包括水、电、气、房屋占用、耗材、日常维护等，由仪器设备所在单位统一管理；

（二）20%作为设备机组人员的酬金，由仪器设备所在单位统一管理；

（三）20%作为学校大型仪器设备维修经费，用于大型仪器设备维修，由实验室管理处统一管理；

（四）10%作为学校大型仪器设备奖励经费，由管理委员会表彰奖励做出突出成绩的单位和个人。

第十一条 服务流程

（一）仪器设备使用者通过网络或电话等形式预约，填写《西北农林科技大学大型仪器设备预约使用申请表》，经机组人员确认，以转账或刷卡的形式缴费后，按预约时间由机组人员或在机组人员指导下完成项目测试。

（二）计财处设立大型仪器设备有偿使用专用账户，大型仪器设备使用者缴费和仪器设备所在单位结算均通过专用账户管理，实现收支两条线、专款专用，任何单位和个人不得私自收取现金或将收入转入校内、外其它帐户。

第四章 补贴管理

第十二条 为充分调动仪器设备占有者与使用者双方的积极性，设立"大型仪器设备共享基金"（简称共享基金），每年纳入财务预算（具体数额根据年度实际运行情况确定），对实验项目测试、实验技术人员培训、新功能开发等予以补贴；

（一）75%的共享基金用于资助大型仪器设备对校内服务。凡使用校、院两级大型仪器设备共享平台内的大型仪器设备，我校科教人员和研究生可按校内价格的 50% 缴费，不足部分由共享基金给仪器设备所在单位予以补贴。

（二）15%的共享基金用于大型仪器设备机组人员的培训提高。机组人员填写《西北农林科技大学大型仪器设备操作技能培训申请表》，经仪器设备所在单位同意、实验室管理处审核，人事处备案后，予以专项支持。

（三）10%的共享基金用于支持大型仪器设备新功能开发。为鼓励开发大型仪器设备的新功能，扩大应用范围，提高利用率，科教人员和机组人员填写《西北农林科技大学大型仪器设备新功能开发项目申请表》，经仪器设备所在单位审核、管理委员会评审后，予以专项支持。

第十三条 共享基金由实验室管理处、计财处负责管理和监督使用。实验室管理处负责对共享基金的使用进行审核，财务处负责统一核算，并定期向管理委员会汇报。

第十四条 实验室管理处、计划财务处、仪器设备所在单位要共同加强对共享基金资助项目的监督检查，对于弄虚作假套取共享基金的行为，情节轻微者给予通报批评和教育，严重者停止开放基金资助并严肃处理。

第五章 考核评价

第十五条 对学校公布的实行有偿使用的大型仪器设备进行年度效益综合考核评价，考核内容包括机时利用、完好程度、人才培养、科研成果、服务收入、功能利用与开发、安全环境等。考核评价结果划分为优秀、良好、合格、不合格四个等级。

第十六条 考核评价工作采取单位自评与学校评审相结合。考核评价结果向全校公布，纳入单位考核指标，并作为大型仪器设备购置论证的主要依据。

第十七条 仪器设备所在单位有偿使用领导小组负责本单位大型仪器设备自

评考核工作。

（一）机组人员通过以大型仪器设备共享管理信息系统获取仪器设备使用运行的各项数据，填写《大型精密贵重仪器设备年度考核评价表》；

（二）仪器设备所在单位的有偿使用领导小组对表中填写的各项数据，进行逐台逐项核实、评分，根据评价标准和等级评出优秀、良好、合格和不合格；

（三）各单位根据自评结果形成总结报告，并对存在问题提出整改意见和措施；

（四）将自评总结报告等材料报实验室管理处，作为学校考核评价的依据。

第十八条 管理委员会负责全校大型仪器设备有偿使用管理工作考核。考核优秀并取得突出成绩者，学校对仪器设备所在单位和机组人员予以表彰奖励；不合格者， 仪器设备所在单位应及时找出原因，限期整改；考核评价连续二年不合格的仪器设备，学校将调拨给校内其它部门管理和使用。

第六章 附 则

第十九条 本办法自公布之日起实施。

第二十条 本办法由实验室管理处负责解释。

二〇〇九年三月十七日

西北农林科技大学大型仪器设备分析测试补贴费使用与管理办法（试行）

校实验发〔2009〕166号

第一章 总 则

第一条 为了进一步提高大型仪器设备的使用效益，促进资源开放共享，根据《西北农林科技大学大型仪器设备有偿使用管理暂行办法》，特制定本管理办法。

第二条 西北农林科技大学大型仪器设备共享基金设立分析测试补贴项目，用于校内教学、科研项目中的分析测试补贴。

第三条 分析测试补贴由实验室管理处、计财处负责管理和监督使用。

第二章 补贴对象

第四条 由仪器设备所在单位申请，经实验室管理处审定并在学校大型仪器设备共享系统内公布的下列仪器设备，均可列入分析测试补贴范围。

（一）单价 10 万元（含）以上的仪器设备；

（二）单价不足 10 万元，但成套配置达 10 万元（含）以上的仪器设备；

（三）单价不足 10 万元，但属于国家有关部门规定为贵重、稀缺的仪器设备。

第五条 凡属我校在编的教师、科研人员、实验技术人员、在读研究生及本科生等，均可申请分析测试补贴。

第三章 补贴申请程序

第六条 凡需申请分析测试补贴者，须登陆西北农林科技大学大型仪器设备共享系统（http://210.27.90.190），根据系统要求，注册成为有效用户，并按系统提示进行网上仪器使用预约，预约成功后，系统自动生成《西北农林科技大学分析测试补贴费申请（结算）单【以下简称申请（结算）单】。

第七条 用户下载打印申请（结算）单，在财务处有项目经费账户的，由课题（项目）主持人签字；无课题（项目）经费的用户需在计财处缴纳费用、由计财处在《申请（结算）单》上盖章。

第八条 用户持课题（项目）主持人签字或计财处盖章的《申请（结算）单》，

即可按照预约安排进行分析测试。

第四章 经费结算

第八条 分析测试补贴的经费额度为分析测试总费用的 50%。

第九条 每月初，设备机组人员持《申请（结算）单》到计财处办理经费结算手续，计财处分别从使用者课题（项目）经费和学校"大型仪器设备共享基金"中划转相关费用到大型仪器设备有偿使用专用账户。

第十条 专用账户的资金分配，按照《西北农林科技大学大型仪器设备有偿使用管理暂行办法》中第十条执行。

第十一条 课题（项目）主持人对《申请（结算）单》签字负责，必须保证课题（项目）经费有足够的支付金额。

第五章 奖 惩

第十二条 使用共享设备获得的成果及发表的论文，应及时反馈到大型仪器设备共性系统中，确认后即奖励一定的免费机时。

第十三条 校内人员不得以自己的名义为校外人员申请分析测试补贴，否则，学校将追究当事人责任。

第十四条 《申请（结算）单》中各项信息必须真实有效，用户伪造信息，除追回补贴费用外，将停止该用户一年以上设备使用权限，并在共享系统中通报批评； 机组人员伪造信息，将按所收入费用的十倍处罚，同时在共享系统中通报批评。

第六章 附 则

第十五条 本办法自公布之日起实施。

第十六条 本办法由实验室管理处负责解释。

西北农林科技大学大型仪器设备新功能开发项目管理办法（暂行）

校实验发〔2009〕291 号

第一章 总 则

第一条 为了不断挖掘大型仪器设备的应用潜力、开发大型仪器设备新功能，更好的为教学科研服务，根据《西北农林科技大学大型仪器设备有偿使用管理暂行办法》，结合我校实际，制定本办法。

第二条 西北农林科技大学大型仪器设备共享基金设立新功能开发项目（以下简称项目），主要用于支持我校大型仪器设备新功能研发和测试分析方法的改进等。

第三条 实验室管理处负责项目的申报评审、组织实施与检查验收等，计划财务处负责项目经费的审核与监督使用等。

第二章 立 项

第四条 新功能开发项目立项范围基本分为三类：

1. 大型仪器设备自身技术性能、测试分析方法（包括软件）的改进与应用范围的扩大等；

2. 废旧仪器设备的重新组装利用与改造改制等。

3. 教学实验室中，对实验教学效果具有显著影响的成套仪器设备改造改制等。

第五条 下列人员均可申请立项：

1. 凡申请进入西北农林科技大学大型设备共享系统、并开展工作的仪器设备，其机组人员均可申请项目；

2. 实验教师、实验技术及实验管理人员均可申请立项支持。

第三章 项目申报与评审

第六条 项目申请每年进行一次，申请人须具备中级及以上职称，或在大型仪器设备管理操作岗位工作 3 年以上的实验技术人员。

第七条 申请人填写《西北农林科技大学大型仪器设备新功能开发项目申请书》，由所在学院（系、中心）审核，主管领导签署意见并加盖公章后，统一上报实验室管理处。

第八条 实验室管理处组织有关专家进行评审，确定支持的项目及经费额度，

报学校批准后实施。

第四章 项目的实施与管理

第九条 项目执行期限原则上不超过两年。项目实行主持人负责制，主持人负责项目方案的制定、经费开支审批及组织实施等。

第十条 项目计划需要调整或延期时，提前 1 个月递交书面报告与更改申请，经实验室管理处批准后方可进行调整或延期，延期时间原则不超过 6 个月。在项目延期执行期内，项目主持人一般不得申请新的项目。

第十一条 项目负责人外出学习、出国或病休半年以上的，需事先提交书面委托代理人报告，由学院审核后报实验室管理处审批，并经实验室管理处主管领导签字后，方可办理主持人转接与原项目移交手续。

第十二条 项目检查于项目计划的中期进行。检查内容包括项目执行档案、实验研究记录、项目经费使用，以及项目执行中存在的问题和改进措施等。

第十三条 项目结题验收工作在项目原计划截止时间后的 1—3 个月内进行。验收程序如下：

（一）项目主持人依据项目计划，书面总结项目执行情况、经费使用情况及项目取得的成果等，经所在学院（系、中心）初步验收后，提交验收意见，报实验室管理处审核。

（二）实验室管理处根据学院（系、中心）的验收意见，组织相关专家到现场进行考察、听取汇报并答疑提问，对项目做出最终验收结论，并在全校范围内予以公布。

第十四条 项目执行期间及结题后形成的论文、专利及研究推广成果等及时上报实验室管理处，作为项目的跟踪管理。

第五章 经费管理

第十五条 学校每年划转一定经费支持项目研究，项目经费由计划财务处下达实验室管理处统一管理，单独建帐，专款专用。

第十六条 项目经费开支范围主要用于项目执行过程中相关的业务费、实验费和材料费，以及少量必需购置的小型零配件等，不得开支培训费、劳务费，严格控制资料费、调研费。

第十七条 与该项目有关的专利申请费、正式出版刊物上发表的研究论文版

面费等，可在项目费中支付。

第六章 奖 惩

第十八条 项目执行过程中，对工作进展迅速、成效显著、意义重大的，学校将给予重点扶持；对因各种原因不能继续的项目，学校将终止立项，并视项目工作实际，全额或部分收回已经支出的经费。

第十九条 项目中期检查中发现未使用经费、未开展工作又无特殊理由的，由实验室管理处收回经费；对于弄虚作假、挪用项目经费等行为，视情节轻重，采取通报批评、追回和停止经费使用等措施予以处理。

第二十条 对于未正常结题验收的项目，学校将收回剩余经费；项目验收后其结余经费转入后续新功能开发项目或下年度大型仪器设备共享基金中使用。

第二十一条 未能按期完成或未通过验收的项目，其负责人与参加人员将取消下一年度大型仪器设备新功能开发项目的申请资格。

第七章 附 则

第二十二条 本办法自发布之日起实施。

第二十三条 本办法由实验室管理处负责解释。

二〇〇九年十月二日

西北农林科技大学关于加强实验技术队伍建设的若干意见

校实验发〔2010〕361号

围绕学校创建"世界一流农业大学"战略目标，按照吸引人才，提高素质，加强管理的工作思路，建设一支以专职为主体的专兼结合的高素质实验技术队伍，以适应研究型大学建设和创新人才培养的需要，现就加强实验技术队伍建设提出以下意见：

一、提高认识，重视实验技术队伍建设

1．各部门要充分认识实验技术队伍在教学科研工作和创新人才培养中的重要性，积极研究解决队伍建设中存在的问题，努力建设一支与学校快速发展相适应的高水平实验技术队伍。

2．建立实验技术队伍建设经费保障机制。将实验技术队伍建设纳入学校人才队伍建设规划，每年从人才建设经费中划拨一定比例，保障实验技术队伍建设中的人才引进及培训工作。

二、充实队伍，保障对教学科研的支撑

3．科学建立实验技术队伍补充计划。根据不同学科实验教学、科研工作及实验室仪器设备配置等方面，按照高水平实验技术人员、急需教学实验人员和一般实验人员分类别，逐年引进和补充，逐步改善实验技术队伍结构。

4．设立大型仪器关键岗。对于拥有大型仪器的公共实验平台，引进国内外优秀的仪器专家，充分发挥高精尖仪器设备的功能，带动和提升学校实验技术队伍整体水平。

5．补充实验仪器维修专职队伍，引进一定数量具有仪器专业背景的工科技术人员。

6．多种形式补充实验技术人员。鼓励科教人员转岗从事实验室的建设与管理工作，通过企业人事代理制度补充一般实验技术人员。

7．推行教师参与实验室工作制度。鼓励高水平教师从事实验教学工作，参与和指导实验室的建设与管理。

三、加强培训交流，提高技术水平

8．加强现有实验技术人员培训。适应实验教学改革，每年对全校实验技术人员统一进行业务培训。每年组织一定数量的实验技术人员到国内高水平实验室学习提高。

9．设立实验技术研究课题和实验技术成果奖，鼓励实验技术人员开展实验创新、仪器功能开发等工作。

10．设立博士学位实验技术人员启动资金，鼓励具有博士学位的实验技术人员开展实验技术研究。

四、改革评聘考核制度，正确引领建设方向

11．改革实验技术系列评聘制度。对实验技术人员晋升专业技术职务时，按照实验技术人员承担的工作任务、实验教学改革、实验技术研发、仪器设备操作等方面进行综合评价。

12．制定科学的实验技术人员工作量核算标准，为科学设岗和量化考核工作提供依据。

13．出台对实验技术人员工作的量化考核办法和措施，实现业绩量化考核，调动工作积极性。

五、改进管理，完善实验室二级管理制度

14．在学院一级推行设立实验室管理中心，统筹协调教学与科研实验室的管理工作。

15．规范实验室主任的岗位设置及聘任，落实实验室主任负责制。

16．活跃实验技术学术氛围，积极组建以教授领衔的实验技术团队。

二〇一〇年十二月二十一日

西北农林科技大学网络管理条例

校网发〔2010〕114号

第一章 总则

第一条 校园计算机网络（以下简称校园网）是学校信息化建设的平台，是进行科研、教学和管理的重要手段，是学校办学的重要基础设施。为规范校园网的管理，促进校园网的应用和健康发展，根据《中华人民共和国计算机信息网络国际联网管理暂行规定》、《中华人民共和国计算机信息系统安全保护条例》以及中国教育与科研网、中国公众数据网的有关规定，结合学校实际情况，制定本条例。

第二条 校园网的建设、运行、维护由学校信息化工作领导小组领导，网络与教育技术中心具体负责。

第三条 校园网用户必须接受并配合有关部门依法进行的检查与监督，采取必要的安全防护措施。

第二章 管理机构

第四条 我校校园网是CERNET的二级接入网络及杨凌城市节点，接受CERNET和西北地区中心网的管理。

第五条 网络与教育技术中心是校园网管理的职能部门，其主要职责是：校园网的规划、设计和运行管理、信息系统管理、用户服务；多媒体技术支持，数字课件、音视频教材制作，教学实况录制、网络教学平台管理；校园卡系统建设与技术维护；全校网络、信息系统及现代教育技术应用的业务指导与培训；全校多媒体教室使用管理、维护、服务。

第三章 网络运行管理

第六条 校园网设施主要包括网络设备（包括交换机、设备箱、机柜、网络插口等）及线路（包括光纤、双绞线、电源配电等），由网络与教育技术中心管理和维护，任何单位和个人不得随意安装或变更。

第七条 接入校园网的各类计算机实验室、教学（培训）公共机房、电子阅览室需对上网用户进行严格管理，建立规范的用户上网登记制度或实名认证制度。

第八条 学校各类网络信息发布服务器（网站服务器）由网络与教育技术中心统一管理并分配虚拟空间，各部门未经许可不得购置服务器等相关设备。

第九条 学校各信息管理（服务）系统技术规范由网络与教育技术中心制订，各部门未经许可不得购置相关软件系统。

第四章 用户管理

第十条 校园网用户可以通过本地、远程和无线三种方式接入校园网，用户接入由网络与教育技术中心具体实施并进行管理。

第十一条 凡学校在册教工和学生都是校园网的合法用户，按照入网账号（学号或工号）认证入网。

第十二条 入网用户的帐号是用户在校园网上的合法标识，为确保个人账号信息安全，用户应妥善保管好自己的用户密码。

第十三条 用户离开西北农林科技大学时，其电子邮箱将继续保留，占用的其它网络资源将被收回。

第十四条 经学校审批建设的各类教学（培训）公共机房的管理者应承担机房内上机用户的管理职责，以保证上网信息安全。

第五章 信息管理

第十五条 根据国家有关政策法规及《西北农林科技大学网站管理办法》、《西北农林科技大学主页信息管理办法》相关规定执行。

第六章 安全管理

第十六条 校园网安全管理工作依据国家有关法规进行，校园网用户必须严格遵守国家有关计算机网络安全的法律法规以及学校的有关条例。

第十七条 校园网仅用于教学、科研和管理等非营利性活动。严禁利用网络从事违反国家法律法规、危害国家安全、泄露国家机密、干扰其他网络用户、侵犯知识产权的活动；严禁利用网络从事商业性活动；严禁在网络上发布未按规定程序进行审查的任何信息。

第十八条 任何单位和个人不得损坏、拆卸、移动和侵占校园网的设备、设施和线路。安置在校园内的设备、设施和线路，确因工作原因需要移动的，由网络与教育技术中心根据技术要求和实际情况进行移动。

第十九条　校园网用户应妥善保管其入网帐号、密码，不得外传、外借入网帐号，并承担管理责任。

第二十条　校园网用户不得利用网络侵入未经授权的计算机或其他网络设备，不得盗用他人身份使用网络资源，不得制作、传播计算机病毒等破坏性程序，不得从事危害校园计算机信息网络安全的行为。

第二十一条　校园网用户如果感染网络病毒影响其他用户，将被提醒采取必要措施进行处理。

第七章　计费管理

第二十二条　依据《西北农林科技大学校园网收费办法》执行。

第八章　处罚

第二十三条　根据学校有关处罚条例，对违反本办法的用户将被警告或停用，情节严重的，将被提交司法部门处理。

第二十四条　对违反本办法，给国家、集体或者他人财产造成损失的，应依法承担民事责任。用户若在校园网上散布和传播反动、色情或其他违反国家法律的信息，校园网的系统日志记录将作为校园网用户违反法律的证据。

第九章　附则

第二十五条　本条例解释权属于学校信息化工作领导小组办公室。

第二十六条　本条例自公布之日起实行。原《西北农林科技大学网络管理条例（试行）》和原《西北农林科技大学校园网络安全管理办法（试行）》同时废止。

西北农林科技大学关于加强实践教学的指导意见

校教发〔2010〕232号

为适应现代农业和社会发展对大学生实践能力和创新精神的要求，提高学生运用现代科技、适应社会和国际竞争的能力，推进我校拔尖创新人才培养模式的改革，提出如下改革意见：

一、适应现代农业和社会发展要求，以能力培养为核心，构建新的实践教学体系

实践教学是实现拔尖创新人才培养目标的重要途径。我校在 70 余年的发展过程中已形成了较为完备的实践教学体系，但与现代农业和社会发展的要求还存在诸多问题和差距，其中较为突出的问题有：实践教学内容陈旧，难于适应现代农业生产的要求；实践教学目标不够明确；实践教学与专业培养目标脱节等等。诸多问题的存在，需要我们依据现代农业和社会对拔尖创新人才的要求，以及创建世界一流农业大学自身发展的需要，群策群力，努力构建新的、适应时代发展要求的实践教学体系。

新的实践教学体系包括：实践教学目标体系、实践教学内容体系、实践教学条件体系和实践教学管理体系。各院（系）应着重围绕实践教学的目标和内容改革开展工作。

本科专业的各项实践教学工作应紧密围绕专业培养目标，对应以下三个方面的内容，分别制定教学目标：一是使学生加深对基础理论知识的理解掌握，熟悉现代农业生产或管理过程和工艺流程；二是使学生掌握现代生产或管理的基本技能；三是使学生具有在实践中对理论知识进行修正、拓展和创新的能力，具备应用新技术和推广新技术的能力。

农科类专业要紧密结合我国现代农业产业发展和服务社会主义新农村建设需要，构建与农业生产相结合、与科技推广服务相结合、与为农村服务相结合的实践教学体系；工科类专业要根据我国现代工业、信息技术等产业发展需求构建与产业发展相结合、与科技创新和技术服务相结合的实践教学体系；理科类专业要加强理论基础与应用科学的有机结合，在实践教学体系中加强理论基础知识的理解与认识，将先进的研究成果应用与解决实际问题相结合；文科类专业要将注

重学生创新思维、创新意识以及用所学知识解决实际问题能力的培养，构建文理综合、体现特色、服务社会的实践教学体系。

新的实践教学体系应按实验教学模块、认知实习模块、专业技能训练模块、社会实践模块、科研训练模块、毕业实习模块设置。

二、紧密结合生产实际，积极引进现代科技成果，大力推进实践教学内容改革

实践教学内容的改革，首先要注重紧密结合生产和社会实际；教学内容必须体现社会经济和科技发展的趋势，及时补充和引进现代科技成果，要将书本知识与现代生产实际紧密结合。

各学院（系）要组织重新修订各专业的实践教学大纲，对各教学环节的内容、目的要求、教学形式和手段、教学所需设施条件、考核办法达到的目标等做出明确的规定。优化和整合教学内容，实施综合实习，避免内容重复。对实验教学内容进行补充、优化整合，进一步减少验证性内容，增加综合性、设计性、研究性内容，鼓励学生运用所学知识进行探索性实践。

注重实践教学的考核，转变过去仅凭平时单一实验或实习报告评定成绩的方法，采取从理论知识、实践技能、创新能力、学习态度、组织纪律、实验实习报告等多方面综合评定，制定出科学的考核标准。

三、加大建设力度，充分调动教师参与实践教学的积极性，确保实践教学改革的顺利推进

针对我校实践教学师资短缺，实验队伍学历层次低，中青年教师实践经验欠缺，高职称教师指导实践教学积极性不高；实验仪器设备老化，台套数不足，教学基地偏少；实践教学方法单一，实践教学组织形式不够灵活；实践教学管理制度和质量监控体系没有完全落实到位等问题，必须加大建设力度，调动教师的积极性，确保实践教学改革的顺利进行。

1. 强化实践师资队伍建设

学校将制定出台相关政策，不断补充实践教学队伍，引导广大教师参与教学改革和研究的积极性。一是要加快加强现有教师特别是中青年教师的培训，首次指导实习的教师要深入场站或企事业单位锻炼 3 个月以上，方可指导教学实习；二是要求高学历和高职称的教师从事实践教学工作；三是聘请校外名师、企事业

单位专家担任兼职实践指导教师，任课或举办讲座、培训等；四是建立科学合理的实践师资队伍激励机制，保证师资队伍的稳定。

2.进一步加大实验室建设力度

学校将进一步加大投入，加快实验室建设步伐，逐步实现实验教学条件现代化。根据当前的规模和发展趋势，学校将结合"985"工程"拔尖创新人才培养"项目，每年投入不少于1000万元，重点用于全校公共基础课程实验设施建设、专业基础实验室建设和新增专业实验室建设。争取经过3～5年的努力，使全校所有教学实验室的装备条件达到国内一流。

3.进一步加大基地建设力度

学校将通过积极争取教育部实践基地建设项目、地方政府和社会投入等途径，进一步加大现有科研推广基地建设，为学生参加教学实习、科研创新训练、毕业设计（论文）等实践教学环节提供必备的保障条件。将科研推广基地建成满足学生实践、科学研究、成果转化与技术推广相结合的试验站，充分满足教学需要。各学院要根据各专业特点找到与基地的结合点，为学生参与科学研究和创业提供条件。

同时，要进一步加强校外实践基地的建设。一方面要吸引和聘请基地所在单位的专家、专业技术人员和管理干部一起参与实习教学环节的管理和指导；另一方面，实习师生要积极帮助基地所在单位开展员工技术培训、科技开发和科研等工作，使实习基地同时成为科技开发和人才培养基地，从而在友好合作、互惠互利的基础上，不断拓展校外实习基地建设的新路子，确保每专业至少具有2～3个固定的校外实践教学基地。

4.狠抓实践教材（指导书）建设

根据实践教学内容和专业培养的要求，结合实践基地的具体情况，组织专家编写具有我校特色的、高水平的系列实践教材（指导书），保证每个专业有1套（系列）实践教材，且随着实践内容的更新而不断修订与完善。实践教材建设要体现"实用、实践、实际、配套"的原则，能够反映现代农业发展的实际需要，以便于学生进行操作和实践。

四、规范运行，加强管理，确保实践教学质量

实践教学的规范化管理是保证实践教学质量的前提，规范管理体制，建立与完善实践教学评价体系，是提高实践教学质量的重要措施。

1.理顺校、院（系）两级实验室管理体制

进一步完善校、院两级实验教学管理体制，实行院长（系）负责制，合理调配教学资源，实现资源共享。实验室管理处为学校主管实验室建设工作的行政机构，全面负责各院（系）实验本科教学实验室的建设和统筹调配工作。

凡承担实验教学任务的实验室以及使用相同或相近仪器设备的实验室，应进行优化整合。所有已建成实验室和实习基地均应面向学生开放，实现教学资源共享，提高建设资金的使用效益。各科研、教学实验室的开放要有明确的开放管理制度和保障制度，学校将把实验室开放作为各单位和各学院（系）教学工作考核的重要指标。

2.变革实践教学的组织形式，规范环节管理

根据各专业实习内容以及实习基地的接纳能力，可采取集中与分散相结合的教学组织形式，充分体现实习内容综合化和实习方式的灵活化，提高实习基地的利用率，保证实习效果。

各院（系）要充分认识到实习教学的地位、作用和重要性，采取有力措施，切实加强实习教学工作，落实好计划、大纲、指导教师、经费、场所和考核等各个实践环节。未经学校批准，不得随意取消或缩短实习时间，也不得随意变更实习计划，以保证实习教学取得应有的效果。

学校将逐年增加学生实践教学经费，保障学生实践教学环节的高质量完成。各教学单位要确保学校下拨的学生实践教学经费能真正用到本科实践教学的各个环节，学校将定期检查和通报经费的使用情况，最大限度地发挥其效益。

3.加强论文与设计环节的指导

论文与设计环节包括学年论文、课程设计、毕业论文（设计）等。课程设计可以作为课程的一部分，在课程教学期内分散进行，也可以作为独立课程集中进行和单独考核。各专业学年论文必须列入人才培养方案，二、三年级学生每年至少完成1篇学年论文。

毕业论文（设计）是整个专业教学过程中的最后一个环节，各学院要进一步加强对本科生毕业设计（论文）的规范管理的质量监控，尤其要加强对毕业设计（论文）的全过程监控，从组织、计划、选题、管理、成绩评定、答辩等各个环节进行全面指导，确保本科生毕业设计（论文）的质量。

4.实施大学生创新性实验计划项目工程

学校将进一步加大大学生创新性实验计划的支持力度，每年资助金额不少于100万元，积极鼓励院系设立科技创新基金。学校将加大项目宏观管理的力度，认真做好项目的立题、评审、中期检查、结题验收和宣传工作，为学生创新能力和科学研究能力培养搭建良好的研究平台。

5.加强社会实践环节的管理

为加强社会实践环节的管理,校团委是指导和组织开展学生社会实践活动的职能部门，各院(系)要成立由书记、院长及团工委负责同志等组成的院(系)社会实践活动领导小组，加强指导和协调；要求学生每学年至少进行1次社会实践活动，并形成调查报告（总结），通过组织汇报、答辩、评比，合格者记入学分，优秀的给予表彰奖励。

6.建立健全实践教学监控体系

学校要修订和完善实验教学、认知实习、专业技能训练、社会实践、科研训练、毕业实习、毕业论文（设计）等实践环节的质量标准及要求。完善教学质量检查制度，加强实践教学过程的动态监控。坚持学期初、期中和期末"三段式"教学检查，采取跟踪实践教学检查、教师评定和学生评价相结合的措施，确保实践教学质量稳步提升。

西北农林科技大学本科专业建设与发展规划（2014-2020年）

专业建设是高等学校最重要的教学基本建设。专业建设水平是衡量一所大学办学水平与实力的重要标志，专业结构与布局是衡量学校办学能力与活力的重要指标。专业建设与发展规划是专业建设的根本依据，是学校有计划地开展各项工作的指导性文件。制订并落实专业建设与发展规划，有助于进一步理清办学思路，明确办学定位，使我校的人才培养工作更好地适应经济建设，社会发展和产业结构战略性调整的需要，使学校各项建设工作纳入科学、规范的轨道。根据《国家中长期教育改革和发展规划纲要(2010－2020 年)》、陕西省《关于深化改革推进高等教育内涵式发展的意见(2014-2020 年)》和《西北农林科技大学总体发展战略规划（2010-2020）》，特制定我校 2014-2020 年专业建设与发展规划。

一、专业现状

目前，我校现有专业 65 个，涉及经济学、法学、农学、文学、理学、工学、管理学和艺术学等 8 个学科门类，其中农学 14 个，文学 1 个，艺术学 1 个，理学 7 个，工学 29 个，经济学 4 个，管理学 6 个，法学 3 个。

在现有 65 个专业中，资环学院的"资源循环科学与工程"、水建学院的"城乡规划"、机电学院的"工业设计"和"包装工程"等 4 个专业暂停招生。

在"十一五"期间，我校共有 12 个国家级特色专业和 18 个省级特色专业。在"十二五"期间，我校共有 12 个专业被列为省级"专业综合改革试点"。

二、指导思想

以邓小平理论和"三个代表"重要思想为指导，深入贯彻落实科学发展观，坚持社会主义办学方向，根据学校总体发展战略规划，以教育思想观念的改革为先导，主动适应国家及区域经济和社会发展的需要，突出学校特色与人才培养特色，进一步优化我校学科专业结构。专业建设要以专业人才培养定位为核心，以社会有效需求为导向，以专业基本建设为基础，以教学内容与课程体系改革为重点，为我校建成产学研紧密结合为特色的世界一流农业大学奠定坚实的基础。

在专业发展中，按照"以农为本，突出旱区农业特色，走综合化发展道路，构建农、理、工、管、经、文、法等多学科协调发展"的总体目标，坚持围绕国家和区域性重大战略需求，进一步强化在在动植物育种、植物保护、农业生物技

术、旱区农业与节水技术、黄土高原水土流失综合治理等领域的专业优势与特色，构建结构合理、优势突出、特色鲜明的专业体系。

三、专业建设基本原则

根据党和国家的教育方针和政策，按照国家教育改革和发展规划安排，严格遵循教育教学规律，围绕学校定位与中长期发展规划，以教育思想和教育观念更新为先导，主动适应国家及区域经济和社会发展的需要，坚持"重需求，建内涵，优结构，求创新，突重点，显特色"的建设原则，逐步形成一个结构合理、规模适当、内涵丰富、特色鲜明的专业体系。

1、坚持"重需求，建内涵"的原则。专业建设要主动适应国家和区域经济社会发展需要，适应知识创新、科技进步以及学科发展需要。注重专业内涵建设，着眼于夯实基础、加强积累、发挥优势。特别对优势学科的优势专业要根据学科发展前沿及时进行专业内涵更新和优化，从而提升专业品质，进而达到专业人才培养质量领先的目标。

2、坚持"优结构，求创新"的原则。要结合国家、区域和本校专业布点和控制情况，建立专业评估与退出机制，综合考虑学校办学资源和专业就业前景，促进教学资源的优化配置和合理调配，实现全校专业结构的优化。同时注重学科之间的融合，积极探索设置新兴、交叉学科的本科专业，积极发展农业生物技术与规范化、标准化、数字化相结合的专业，培育新的专业发展的增长点。

3、坚持"突重点，显特色"的原则。根据学校本科专业发展现状及学校未来发展定位，着力在动植物育种、旱区农业与节水技术、水土流失综合治理等领域的重点专业建设，突出"立足旱区，服务三农"的专业办学特色。

四、专业建设目标

1、总体目标

巩固优势特色专业，不断调整和优化专业结构，逐步构建成产学研紧密结合特色鲜明的拔尖创新人才培养体系。到2020年，学校本科专业控制在70个左右。

2、传统专业建设目标

一方面，加强专业内涵建设，从不断改革课程体系、充分结合学科前沿对一些传统专业进行调整改造。传统专业要做精，要保持优势，要充分体现学校的教学水平和学术水平；另一方面，加强对一些老专业的调整改造，对于不适应社会

和经济发展的、就业率低的、就业质量较差的专业实行"转、并、裁"的专业退出机制。

3、新专业建设目标

积极加强学科专业间的交叉与融合，大力培植专业新的生长点。到2020年，预计新增设专业5-6个，新增设专业一方面来自于传统优势专业衍生出来的新的专业增长点；另一方面集中在面向国家战略需求的旱区农业、生态文明、农业现代化及农业标准化等学科领域

4、优势专业建设目标

继续建设好12个国家级特色专业、18个省级特色专业和12个省级"专业综合改革试点"。积极推进相关专业的工程教育认证工作。推动葡萄与葡萄酒工程专业国际认证工作。

五、专业建设的措施

1、明确专业定位与特色

学校在专业建设的过程中要加强宏观调控，整体上把握专业建设方案。各院系要把专业结构调整和专业建设作为院系战略发展、学科建设及人才培养规划的重要内容，要能结合发展目标定位进行专业建设，使专业建设落到实处。学院要根据自身研究型学院或教学型学院等定位，对不同类型的专业，制定和实施不同的调整与建设实施计划。每一个专业必须结合经济社会发展需要，找准在国内外的定位，把握发展方向，形成专业特色。学校积极鼓励研究型学院逐渐实现按学院或学科门类招生和培养。

2、突出创新创业能力，设计人才培养方案

认真探索高等教育进入大众化阶段后人才培养的质量标准，深入研究经济社会发展对各类人才需求的趋势，以培养学生创新精神与实践能力为出发点，以学生的可持续发展为基本要求，明确培养目标，改革传统人才培养模式，构建与社会发展和学校特色相适应的人才培养方案。

3、加强专业课程体系建设和改革

根据学校学科专业的布局，按照学科门类搭建统一的学科基础课平台；借鉴国内外同等学校相近专业的教学计划或培养方案，结合本校人才培养定位与特色，进行课程体系的整合和改革，建立起科学合理、界限明晰的专业课程体系。完成

开设课程的质量标准建设工作，鼓励编写课程相关教材，尽快将本学科新的优秀学术成果反映到教学内容中去。

4、加强专业师资队伍建设

要建立起一支教学水平高、科研能力强、梯队合理，符合新时期高校特点，能够满足专业教学需要的师资队伍。加强学术创新团队和教学团队建设。采用引进与培养相结合的机制，通过各种途径引进高层次人才和学校专业发展急需的短缺人才，完善人才引进激励机制，吸引各类高层次人才主动加入；抓紧提升学校整体师资队伍的学历层次和职称层次，鼓励中青年教师到国内外提升学历、进修或者访学。开展各类教师教学技能培训或比赛，不断提高教师教学水平。

5、加强实验室和实习基地建设

加强实验室管理，充分发挥国家级、省级实验教学示范中心的辐射带动作用，积极推进实验教学内容、方法和形式的改革，构建立体型实验教学体系。加强实践教学基地建设，加快学校自有农业科技试验示范站、示范基地、专家大院等农业推广基地的教学服务改造，建成"以产业推广基地为基础，产学研紧密结合"的实践教学模式，提高学生的实践能力与创新能力。

6、加强教学研究、改革与实践

教务处要组织各院系开展高层次的，具有前瞻性、探索性的规划类教学改革立项研究，要对拔尖创新人才培养模式、专业教学内容、课程体系等方面进行不断的探索与改革。教师教学能力发展中心要组织教师立足课堂开展教学方式与手段等方面的改革与实践。积极促进教研与教改良性互动，形成一些针对性强、目的明确、指导意义重大且具有可操作性的教学改革成果。

7、加强对外交流合作

坚持把加强国际交流与合作、实施国际化战略作为专业建设发展的重要途径。认真学习借鉴国内外先进的学科专业建设经验，吸引国内外著名学者参与和指导学科专业建设，面向海外公开招聘杰出学术带头人；通过积极开展教师交流、学生交换、课程交流、合作办学等形式，加强与国内外高水平学科专业的合作，不断开阔视野，打造特色学科专业品牌，提升学科影响力。

8、建立健全专业建设相关制度

重视专业评估工作，建立健全专业评估制度，要制定和实施《西北农林科技大学大学本科专业评估办法》对本科专业建设情况进行评估和评议。学校将按照专业评估流程逐一梳理专业建设中的问题，明确专业建设发展的特色和方向，为形成学校的专业优势和专业特色奠定良好的基础。同时，要建立专业奖惩与退出机制。对于人才需求量大、办学条件好、就业形势好的专业，要给予大力扶持并适度扩大招生规模。对于疏于建设、社会需求量小、就业情况不好的专业，要及时进行整顿、改进和建设，适当压缩招生规模，或实行隔年招生。对于办学条件差、学生就业困难的专业，要采用"转、并、裁"等方式予以调整。

西北农林科技大学人员分类管理指导意见

校人发〔2014〕94号

一、指导思想

以科学发展观为指导，深入贯彻落实学校第二次党代会精神和"十二五"规划，以建设世界一流农业大学为目标，根据人才培养、科学研究、社会服务和文化传承创新的需要，按照高等学校人员职业特点，建立分类科学、结构合理、职责明晰、管理规范的人员分类管理制度。以合理配置教育人力资源、全面提高教育教学水平和质量、提升科技创新能力为导向，以加强高水平队伍建设为核心，建立健全竞争机制和激励机制。进一步深化校院两级管理体制，落实二级学院办学自主权，强化岗位意识，明确岗位职责，激发各类人员的内在活力，积极引导教职员工围绕学校总体发展目标和要求，立足本职岗位，发挥专业特长和自身发展潜能，为建设世界一流农业大学提供坚强的制度保证和人才支持。

二、基本原则

（一）按需设岗，分类管理

按照高等学校工作特点和国家有关政策，将全校工作岗位分为专业技术岗位、管理岗位和工勤技能岗位三类。依据学校的办学目标与发展定位，科学、合理地设置学校岗位总量以及专业技术岗位、管理岗位和工勤技能岗位的岗位数量，并结合各类岗位的特点与工作性质，分别提出岗位管理的指导意见。

（二）院部为主，宏观指导

落实二级学院办学自主权，充分发挥院部在校院两级管理中的主体地位作用。学校根据年度重点工作和长远发展规划，对各单位提出年度和聘期目标任务与要求，并进行宏观指导。院部根据学校的宏观指导意见，结合岗位特点与工作性质，制定符合职业特点的工作职责。

（三）细化职责，量化管理

各单位以有利于推进学科建设与发展、有利于提高教育教学质量、有利于提高科研水平、有利于调动广大教职工工作的积极性和主动性为出发点，根据学校的目标任务与要求，结合学科建设、专业建设、教学任务、科学研究任务以及实

际承担的工作任务等，自主制定符合本单位实际、具有可操作性、可以相对量化考核的各类各级岗位详尽职责。

（四）目标管理，规范考核

学校与受聘人员签订岗位聘用合同，明确聘期岗位职责和聘期工作任务要求。根据岗位工作特点，实行聘期考核与年度考核相结合的考核方式，其中教师岗位以聘期考核为主，其余岗位以年度考核为主。

三、岗位分类

我校所有工作岗位分为专业技术岗位、管理岗位和工勤技能岗位三种类别。

（一）专业技术岗位

专业技术岗位指从事专业技术工作，具有相应专业技术水平和能力要求的工作岗位。专业技术岗位分为教师岗位和其他专业技术岗位，其中教师岗位是主体。

1. 教师岗位

教师岗位包括具有教育教学、科学研究、科技服务工作职责和相应能力水平要求的专业技术岗位。根据教师在教学、科研、社会服务等方面所侧重承担的主要职责，将教师岗位分为教学为主型岗位、教学科研型岗位、科研为主型岗位和科研推广型岗位四种类型。

教学为主型岗位指承担全校本科生通识类课程的教师岗位。主要指以承担本科生数学、物理、外语、思政及体育等公共基础课教学任务为主的教师。

教学科研型岗位指承担学科大类基础课、学科基础课和专业课程教学任务的教师岗位，兼有教学、科研任务。教学科研型岗位是教师岗位的主体。

科研为主型岗位指以承担科学研究任务为主的教师岗位。

科研推广型岗位指以承担科学技术推广、成果转化、向社会提供技术服务为主的教师岗位。

2. 其他专业技术岗位

其他专业技术岗位指从事教育教学、科学研究辅助工作或为教学科研工作提供管理服务的专业技术岗位。根据岗位性质、任务特征、服务对象和学校发展定位，将其他专业技术岗位分为教学实验岗位、科研实验岗位、图书档案岗位、新闻出版编辑岗位、医疗卫生岗位、农业（林业）技术岗位和其余专业技术岗位。

（二）管理岗位

管理岗位指担负领导职责或管理任务的工作岗位。包括校、院（系）以及其他内设机构的管理岗位。

（三）工勤技能岗位

工勤技能岗位指承担技能操作和维护、后勤保障、服务等职责的工作岗位。

四、各类岗位的基本条件

（一）遵守宪法、法律、法规和学校的各项规章制度。

（二）爱岗敬业，具有良好的职业道德和品行。

（三）满足岗位所需的专业、能力或技能条件。

（四）符合国家规定的相关职（执）业资格准入条件。

（五）适应岗位要求的身体条件。

五、各类岗位的基本要求

（一）专业技术岗位

1.教师岗位

教师岗位基本要求由教学任务、科学研究（教学研究）任务和社会服务任务三部分基本任务组成。

教学任务：由教学工作量、教学质量和其他教学活动三部分构成。包括为本科生和研究生课堂授课（含专题）、指导学位论文（含本科生毕业设计）、实验实习、实践教学、学业导师、指导大学生科技创新和学科（学术）竞赛、批改作业、课堂讨论、指导大学生科研训练、参与教学实践基地建设等。

科学研究任务：包括主持（参加）科研项目、到位科研经费、发表学术论文、出版学术专著、科普著作、获得科研、推广成果奖励、审定品种、获得授权发明专利和获得具有本学科特色的成果奖励（如艺术作品、体育竞赛等）、科技成果推广、科技服务、组织或参加学术活动等。

教学研究任务：包括参加教学研讨活动、主持（参加）教改项目、发表教学研究论文、编写出版教材、获得教学成果奖励以及在教学环节已经应用、得到学校认可、可以在全校教学中推广、借鉴的教学方法、教学组织模式等成果。

社会服务任务：包括面向社会提供科技服务和参与本单位公益性活动两部分。其中，参与本单位公益性活动包括学科建设，专业建设，课程建设，实验室建设，学科发展规划、评估、申报，平台与基地建设、团队建设等与学科发展有关的任

务；担任班主任、教研室（系）、党支部、工会等负责人；担任党委（党总支、党支部）委员、工会委员、工会小组长等；承担党务工作、行政事务、学生日常教育与管理、社团指导教师等；在国际国内学术组织任职、国际国内期刊担任编委等。

2.其他专业技术岗位

其他专业技术岗位基本要求由工作任务、工作研究和公益活动三部分组成。

工作任务：保质保量完成本单位规定或分配的工作任务；服务对象满意。

工作研究：结合本职工作开展（参与）探索性研究，包括主持（参与）研究项目、发表研究论文、撰写调研报告、出版实验（实习）指导书、仪器设备使用说明书等。

公益活动：参与单位发展规划、实验室建设等与本单位发展或提高教学科研水平、服务质量和服务水平有关的任务；担任班主任、实验室（科室）、党支部、工会等负责人；担任党委（党总支、党支部）委员、工会委员、工会小组长等；承担党务工作、行政事务等以及参与本单位组织的其他公益性活动。

（二）管理岗位

管理岗位基本要求由工作任务、工作研究和公益活动三部分组成。

工作任务：保质保量按时完成学校或本单位规定或分配的工作任务和年度重点工作任务；严格执行校党委和校行政的决策、决定；督促相关部门按期保质保量完成安排的工作任务等；服务对象满意。

工作研究：结合本职工作开展（参与）探索性研究，撰写调研报告或发表与本职工作相关的研究论文等。

公益活动：担任班主任、党支部、工会等负责人；担任党委（党总支、党支部）委员、工会委员、工会小组长等以及参与本单位组织的其他公益性活动。

（三）工勤技能岗位

工勤技能岗位基本要求由工作任务、工作探索和公益活动三部分组成。

工作任务：保质保量完成本单位规定或分配的工作任务；服务对象满意。

工作探索：参与业务培训、工作指导、技术革新等。

公益活动：担任党支部、工会等负责人；担任党委（党总支、党支部）委员、工会委员、工会小组长等以及参与本单位组织的其他公益性活动。

六、岗位考核

（一）考核原则

1.实行年度考核与聘期考核相结合的考核方式。教师岗位以聘期考核为主（每个聘期三年），年度考核主要考核各项工作进展情况。其他专业技术岗位、管理岗位和工勤技能岗位以年度考核为主，聘期主要考核履职情况。

2."双肩挑"人员和受聘教师岗位兼任学院（系、部、所）党政领导职务的人员，聘期内以管理工作考核为主，教学、科研任务减免2/3。

3.辅导员和学工秘书按照管理岗位进行年度考核和聘期考核。

4.所有人员考核工作由岗位聘用单位负责。其中"双肩挑"人员的管理工作考核由所在部门负责，业务工作考核由专业技术岗位聘用单位负责。

（二）考核组织

1.年度考核由人事处负责组织实施，依据教职工履职情况决定考核结果。

2.聘期考核由学校统一安排部署，各单位组织实施。依据教职工聘期内工作任务和岗位职责完成情况决定聘期考核结果。

（三）考核结果应用

1.年度考核合格及以上者，按照国家工资政策，次年正常晋升一级薪级工资。

2.聘期考核结果将作为校内薪酬待遇发放、专业技术职务晋升、职员职级晋升、工人等级考评和下一轮岗位聘用等工作的重要参考依据。

七、组织实施

（一）成立组织机构

为保证人员分类管理方案的顺利实施，学校成立人员分类管理领导小组和考评督查办公室，二级单位成立工作机构。

1.成立人员分类管理领导小组

校党委书记和校长任组长，主持制定人员分类管理的相关政策和各类各级岗位的基本岗位职责。

领导小组下设工作机构。工作机构由分管人事工作的校领导负责，具体工作由人事处承担。

2.成立学校考评督查办公室

考评督查办公室主要职责是对各单位上报的岗位职责和工作任务等进行评估、审核；监督二级单位的聘期考核工作；对二级单位年度工作任务进行检查、督察和考核。

3.二级单位工作机构

二级单位成立由党政领导、工会负责人、教职工代表组成的工作机构，主要负责根据本指导意见的基本精神，在完成学校下达的各项工作任务的前提下，制订符合本单位实际的各类各级岗位人员的详尽岗位职责。

（二）聘用管理

1.学校对岗位聘用工作实行统一设岗、分级聘用。

2.所有聘用人员的日常管理和考核工作由各二级单位负责，人事处代表学校进行监督、检查。

3.二级单位代表学校与每一位受聘人员签订聘用合同，明确聘期内工作任务和岗位职责。

（三）二级单位制订岗位职责的基本要求

学校制定的各类各级岗位的岗位职责为基本职责，各二级单位在保证学校下达或分配的各项工作任务顺利完成的前提下，按照以下基本要求，制定符合本单位实际、具有可操作性、具体的详细岗位职责。

1.以完成本单位承担的教学任务和学校下达的目标任务为基本要求，以促进学科建设与发展、专业建设为根本目标，确保学校教学、科研和社会服务等各项工作任务顺利完成。

2.制定的岗位职责要符合岗位性质和特点，有利于保质保量完成学校下达的各项工作。

3.教师岗位职责中教学任务、科研任务和社会服务任务三者之间不能相互替代；教学任务中本科生课堂授课任务不能用其他教学任务替代。

4.各单位制定的人员分类管理办法和岗位职责要经过本单位教代会或职工大会讨论通过，上报学校评估、审核、备案后实施。

5.科研推广型教师岗位职责由相关学院会同科技推广处制定，并经相关学院讨论通过，上报学校评估、审查、备案后实施。

西北农林科技大学危险化学品安全管理办法

校国资发〔2014〕427号

第一章　总　则

第一条　为了加强危险化学品安全管理，树立"安全第一，预防为主"的思想，保证学校教学、科研工作的顺利进行，保障师生员工人身及国家财产安全，保护环境，根据国务院《中华人民共和国安全生产法》、《危险化学品安全管理条例》及《易制毒化学品管理条例》等法律法规及省部有关文件精神，结合我校实际，制定本办法。

第二条　本办法所称危险化学品，是指由国务院安全生产监督管理部门会同国务院工业和信息化、公安、环境保护、卫生、质量监督检验检疫、交通运输、铁路、民用航空、农业主管部门，根据化学品危险特性的鉴别和分类标准确定、公布的《危险化学品名录》，所列具有毒害、腐蚀、爆炸、燃烧、助燃等性质，对人体、设施、环境具有危害的剧毒和其他化学品。

第三条　本办法适用于学校教学、科研及服务等工作中危险化学品的购买、运输、储存、使用、管理和处置等过程。

第四条　从事购买、储存、使用、销毁危险化学品和处置废弃危险化学品等活动的单位和从业人员，必须接受安全知识、岗位专业技术、安全卫生防护和应急救援知识的培训，并经考核合格后方可上岗作业；对有资格要求的岗位，应当配备依法取得相应资格的人员。

第二章　管理机构及职责

第五条　学校国有资产管理处是我校危险化学品管理的监管部门，负责制订学校危险化学品相关管理办法，监督检查危险化学品的使用管理和整改工作，负责危险化学品从业人员的技术培训与资格认定工作。

第六条　学校国有资产管理处物资供应与调配中心负责全校危险化学品的供应、报减及废弃物的回收处置工作，办理危险化学品的许可、申报与购买等手续，校内各使用单位，不得私自采购。每年初，学校物资供应与调配中心向计财处提供全校危险化学品购置目录，自行采购的单位和个人计财处不予报销。

第七条　　学校教务处与科学技术研究院分别负责全校教学实验室、科研实验室各类危险化学品的使用过程管理。各学院（系、部、所、重点实验室）为危险化学品安全使用的直接责任单位，负责制订落实本单位危险化学品管理制度、操作规程、应急预案等，负责本单位危险化学品的安全使用和日常管理。

第八条　　凡涉及使用危险化学品的实验室应建立危险化学品管理台账制度，对危险化学品领取、使用、储存及销毁等进行登记备案。

第九条　　各相关单位在新建、改建与扩建教学、科研场所或设施时，凡涉及危险化学品应预先向国有资产管理处、基建规划处等单位提供关于危险化学品安全要求及防范措施等资料，经安全条件论证、审批后方可实施。项目建成后，须经安全验收后，方可投入使用。

第三章　　购买与运输

第十条　　学校各教学、科研实验室需要购买 危险化学品时，须提前 20 个工作日，由使用人填写《西北农林科技大学剧毒（易制毒）化学品申购表》，实验室主任、单位负责人签字批准并加盖单位公章后，报国有资产管理处物资供应与调配中心。国有资产管理处按照地方行政主管部门规定，办理报批手续。

第十一条　　采购危险化学品时，根据危险化学品的类别，分别到公安或者工商部门指定的具有危险化学品经销权的公司进行采购。

第十二条　　危险化学品的运输，按照公安和交通部门的规定必须交由有资质的公司运输。危险化学品转运需按相关法律、法规执行，遵守专车专用、专人随车负责的原则，运达立即履行移交、检验及入库手续。运输危险化学品的车辆及容器，用后必须进行彻底清理、消毒等处理。

第十三条　　学校物资供应与调配中心向各单位运送危险化学品时，必须是专人负责、专车运送，必须向运送人员交待有关注意事项，防止意外事故的发生。

第十四条　运输危险化学品的车辆，应按规定悬挂危险品字样的标志，并严禁烟火。

第十五条　碰撞、互相接触、摩擦容易引起燃烧、爆炸或造成其它危险的物品，以及化学性质或防护、灭火方法互相抵触的危险化学品不得违反配装限制和混合配装。

第十六条 遇热、遇潮容易引起燃烧、爆炸或产生有毒气体的危险化学品，在装运时按规定应当采取隔热，防潮措施。

第四章 储存和保管

第十七条 国有资产管理处物资供应与调配中心设立危险化学品贮存专用库房。各学院（系、所）因实验需要，经国有资产管理处物资供应与调配中心和保卫处审核、批准后，可以设立危险化学品贮存专用库房，用于短期、少量贮存部分危险化学品。未经批准不得设置危险化学品贮存专用库房。

第十八条 储存危险化学品的实验室或库房应当根据其生产、储存危险化学品的种类和危险特性，设置相应的监测、监控、通风、防晒、调温、防火、灭火、防爆、泄压、防毒、中和、防潮、防雷、防静电、防腐、防泄漏以及防护围堤或者隔离操作等安全设施、设备，并按照国家标准、行业标准或者国家有关规定对安全设施、设备进行经常性维护、保养，保证安全设施、设备的正常使用。

第十九条 储存危险化学品的场所及设施，应当设置明显的安全警示标志、通信和报警装置，并保证有效可用。由专人和兼职人员负责管理；剧毒化学品以及储存数量构成重大危险源的其他危险化学品，应当单独存放，并实行双人保管、双人领取、双人使用、双人双锁、双本账的"五双"制度，精确计量、记录，防止被盗、丢失、误领、误用。并在国有资产管理处备案。

第二十条 各学院及有关单位每年11月底对所管理的危险化学品进行全面清查，并将当年消耗量和年底库存量经单位主管领导签字后报国有资产管理处，确保帐物相符。暂存在学校物资供应与调配中心的危险化学品存放期限为壹年，如下年使用，须办理延期手续。超过有效期限的按规定办理报废手续。

第二十一条 压缩气体（易燃、易爆、腐蚀、助燃、剧毒等）钢瓶必须放在特制的铁皮柜或单独房间内，不可靠近热源。装有可燃、助燃气体的气瓶应距明火距离不得小于10米。禁止敲击和碰撞，专瓶专用，禁止私自改装。化学性质相抵触可能引起燃烧、爆炸的气瓶应分开存放。不得使用过期未检验的气瓶。各种气瓶必须按期进行技术检验，发现有严重腐蚀或损伤时，应提前进行检验。

第五章 申领和使用

第二十二条 危险化学品必须由两个及以上人员办理领用手续，应严格"按需领取"，持相关负责人审核并加盖公章的《危险化学品领用申请表》，到学校

物资供应与调配中心库房办理领用手续。对于剧毒类危险化学品的使用，原则上规定尽量使用替代品，必须使用的须将未使用完的及时交回学校物资供应与调配中心库房，并做好移交登记。如需使用危险化学品野外实习等，相关实验人员需提前在国资处办理临时存放申请。

第二十三条　使用危险化学品的实验室应当具备相应的法律与法规规定、国家及行业标准规定的安全条件，设置相应的监测、通风、防晒、防火、防爆、防毒、防腐等安全设施，并根据所使用的危险化学品种类和危险特性、使用量与使用方式，建立健全相应的安全管理规章制度和安全操作规程，保证危险化学品的安全使用。

第二十四条　使用危险化学品的实验室，须每年将危化品管理人员信息报国有资产管理处定期组织培训，取得相应资格后方可上岗工作；必须对进行危险化学品实验和参与实验的教师、学生及其他人员进行安全法规和技术操作培训，合格后方能进入实验室。

第二十五条　使用危险化学品的实验室应张贴下列信息内容：

（一）分类和标签信息；

（二）物理、化学性质；

（三）主要用途；

（四）危险特性；

（五）储存、使用及运输的安全要求；

（六）出现危险情况的应急处置措施（或应急预案）。

第二十六条　使用危险化学品进行实验时，必须由两人及以上人员同时操作，建立使用管理档案，使用记录（包括使用时间、使用人、用量和用途等）。剧毒化学品和易制毒化学品的使用管理档案须报学校物资供应与调配中心备案，作为再次领用的验收条件。

第六章　处　置

第二十七条　国有资产管理处负责全校危险化学品及其废弃物的处置工作，安排相关人员定期进行回收，委托经由陕西省环保厅审核、并具有合法资质的机构进行处置。

第二十八条 各使用单位须指定专人负责收集、处理、存放、监督及检查有毒有害废液与废固物的管理工作，对过期与破损的危险化学品、盛装危险化学品空容器及危险化学品的废料、废液、废渣等，要随时分级、分类收集和定点存放，不得随意丢弃。

第二十九条 危险化学品进行回收转移、剧毒化学品进行销毁处理，均需严格办理登记交接手续，剧毒化学品还必须在本部门和国有资产管理处备案存档。

第七章 罚 则

第三十条 对于未经批准，违反规定自行采购危险化学品和设立危险化学品储存库房的单位，学校将追究单位负责人责任。

第三十一条 发生危险化学品事故，其单位主要负责人应当在第一时间按照应急预案采取有效措施，尽量减少事故损失，并及时向本单位主管领导、学校主管部门和当地公安部门报告。

第三十二条 对于违反危险化学品管理规定、存在重大安全隐患不及时整改、发生安全事故处置不力、以及谎报、瞒报等情况，学校将依照有关规定给予相应处理；构成犯罪的，由司法机关依法追究其刑事责任。

第八章 附 则

第三十三条 本办法自发布之日起执行，原（校实验发〔2008〕175号）《西北农林科技大学危险化学品安全管理办法》同时废止。

第三十四条 本办法由国有资产管理处负责解释。

西北农林科技大学本科专业设置与建设管理办法（修订）

校教发〔2016〕414号

第一章　总　则

第一条　为规范我校本科专业建设与管理，发挥学院（系）在专业建设中的主体作用，优化专业结构，突出专业特色，提升专业建设水平，结合学校实际，特制定本办法。

第二条　本科专业建设的基本原则是统筹规划，分类指导，突出重点，特色建设，注重内涵，形成品牌，动态调整，提升质量。

第二章　专业设置

第三条　专业的设置要符合国家经济建设和社会发展需要；符合教育部颁布的《普通高等学校本科专业设置管理规定》、《普通高等学校本科专业目录》等政策要求；符合学校办学定位、办学目标和办学特色；符合和达到学校专业设置的基本标准或条件要求。

第四条　专业设置工作每年集中进行一次。学院（系）申请设置新专业，或调整专业名称、学位授予门类，需经学院（系）教授委员论证、学校教学指导专门委员会审议、校长办公会审定通过后，按教育部规定程序办理。

第五条　新专业经教育部审批后方可进行招生。现设专业连续五年不招生的，原则上按撤销专业处理。撤销专业由学校报教育部备案。

第三章　专业建设与管理

第六条　统筹规划。专业建设实行校院两级管理。学校对专业建设进行宏观指导和统筹规划，适时调整和优化专业布局与结构，建立健全专业建设管理制度，对专业建设资源进行有效整合和合理配置。各学院（系）是专业建设的主体，应把本科专业建设作为学院（系）战略发展和人才培养的重要内容，加强专业内涵建设，不断强化专业优势与特色，负责将本学院（系）专业建设的组织、协调、实施等落到实处。

第七条　分类指导。学校对专业实施分类管理，分类指导。

（一）建设新专业。对于新办专业，重点加强实验教学条件、实习基地、教学师资队伍建设，加强对新办专业评估检查，逐步形成新专业自我约束、自我发展的长效机制，培育新的专业增长点。

（二）打造品牌专业。对于具有明显学科优势和特色的专业，通过重点投入、重点建设、精心打造，建设一批具有示范和辐射作用的品牌专业，跻身国内一流行列。

（三）改造老专业。对于专业基础较好，但招生吸引力不足、就业存在一定困难的老专业，应用现代信息技术、生命科学技术及现代工业技术等进行改造，提升专业核心竞争力。

（四）专业调整。建立专业预警与退出机制，对学科水平低、办学条件差、教学管理不善及招生就业困难的专业，减少或停止招生。

第八条 内涵建设。学院（系）系统推进本学院（系）专业在人才培养模式、课程和教学资源、师资队伍、教学方法手段、实践教学、教材、教学管理等专业发展重要环节的综合改革，进一步深化专业内涵建设。

第九条 资源优化配置。学校建立基于学科专业发展水平和目标定位的资源配置原则与标准，配置学院（系）相应教育教学资源，由学院（系）根据专业建设规划自主管理和使用，学校按专业建设绩效动态调整。学院（系）按学科专业相同相近原则，对教学实验室、实践教学及创新创业教育基地、教学团队、优质课程等资源进行优化整合，集成学科专业资源，发挥整体优势，提高专业核心竞争力。

第十条 专业建设实行项目管理。学校实施"专业综合实力提升计划"，设立专业建设类项目，重点开展新专业建设、品牌专业建设、老专业改造以及工程教育专业认证等。专业建设项目管理按照学校相关管理办法执行。

第十一条 专业建设实行专业责任教授负责制。学院（系）聘任专业责任教授，负责制定本专业建设规划和专业质量标准，制（修）订专业人才培养方案等。

第四章 专业评估

第十二条 学校开展本科专业评估，制定专业评估标准；学院（系）开展专业自评工作。原则上每 4 年开展一轮评估。

第十三条 专业评估是对专业建设的评价、监督和保障，也是对学院（系）评估的核心内容。评估结果将作为专业建设、专业预警、专业调整和学院（系）工作考核评价等工作的依据。

第五章　附　则

第十四条 本办法自发文之日起执行，原《西北农林科技大学本科专业设置管理办法》（办（教）发〔2001〕73 号）同时废止。

第十五条 本办法由教务处负责解释。

西北农林科技大学教学实验室建设项目管理办法

校教发〔2016〕419号

第一章　总则

第一条　为了加强和规范我校教学实验室建设项目管理，确保项目建设取得成效，根据《西北农林科技大学修购专项资金及项目管理办法》（校财发〔2012〕391号）及《西北农林科技大学预算管理办法》（校财发〔2016〕368号）的有关规定，结合我校教学实验室的实际，特制定本办法。

第二条　本办法所指的教学实验室建设项目是指中央高校改善基本办学条件专项资金（仪器设备类）以及学校投入的其它资金用于教学实验室等教学条件建设的项目。

第三条　教学实验室建设按照校、院两级管理的原则，遵循申报、论证、立项、实施、验收、效益评估的程序，实行项目管理。

第二章　组织管理

第四条　教务处是教学实验室建设项目的归口管理部门，各院（系）是教学实验室建设项目的申报与执行部门。

第五条　管理职责：

（一）教务处的主要职责是：

1.提出学校教学实验室建设项目规划以及跨院（系、部）的项目建议；

2.组织项目申报，审核、整理、汇总项目申报文本；组织项目评审；

3.审核项目执行计划，监督落实项目实施；

4.负责项目检查、验收和绩效考核；

5.建立项目档案立卷。

（二）各院（系、部）主要职责是：

1.以院长（主任）或分管教学副院长（副主任）为负责人，做好教学实验室建设项目规划；

2.提前做好项目储备；组织编制项目申报文本；对所申报项目组织论证，提出本部门项目建议；

3.建立项目工作责任制，落实项目实施计划；

4.配合相关部门做好项目验收和绩效评估工作；

5.做好项目档案的归档和管理工作，并报教务处备案。

第三章 项目申报

第六条　学校在每年 3 月底前安排一次实验室建设项目集中申报。各院（系）要统筹规划，每年申报以后三年的实验室建设项目。项目一般以院（系、部）为单位进行申报，也可以和其他部门联合申报。

第七条　项目申报的原则：

1.满足教学原则。应按照学校教育教学发展规划、专业人才培养方案以及教学质量标准的要求进行规划。要求本科实验开出率达到 100%。专业实验室能够开设综合性、创新性实验项目。

2.布局合理原则。满足教学的实验室布局和良好的环境，充分考虑到扩展实验教学内容、改进实验教学方法和延伸实验室功能的后续要求，为实验室规格提升和持续发展做出必要安排。

3.资源共享原则。各学院（系）内部必须认真整合资源，同时改革实验室管理体制和仪器设备管理使用体制,组建学院(系)级实验教学中心，并由学院(系)实验教学中心统一仪器设备的管理和使用，实现资源的最大程度共享，避免重复建设、重复购置。

4.适度超前原则。在满足教学实验基本要求的前提下，各实验室尤其是专业实验室可以在技术上考虑适度的创新性和超前性。设备的添置要有前瞻性和先进性，满足优化实验课程，保证教学质量和现代教学要求。

第八条　项目申报的范围：

1.到使用期限且无维修价值的老旧仪器设备更新。

2.因台套数不足，需要补充的仪器设备。

3.新办专业、经学校批准新开实验项目或更新实验内容所需增加的仪器设备。

4.学校批准的需要由教学设备经费扶持的项目。

第九条　项目申报的程序：

1.项目申报部门要明确项目负责人、技术负责人等项目组人员，将项目责任落实到人。要组织系、教研室主任及有关教师，在广泛征求意见、深入讨论和充分调研的基础上，填写《西北农林科技大学教学实验室建设项目申报书》。

2.项目申报部门组织相关人员对申购仪器设备的功能、先进性、配置、技术参数、报价等进行市场调研。若申报有大型仪器设备的，填写《西北农林科技大学大型仪器设备论证报告》。

3.院（系、部）负责人组织相关教师和专家（不少于5位）对申报材料及申报的大型仪器设备进行论证，并签署专家论证意见。

4.项目申报书经本学院（系、部）院长（主任）审核签字并加盖公章后连同论证材料一并报教务处审核。

第四章 立项审批

第十条　学校教学指导专门委员会从以下几方面对申报项目进行综合评审：

1．建设项目的内容、投资；目前现状与教学要求的差距；通过建设能达到的水平；能承担的教学实验任务；预期发挥的效益；

2.建设项目需购置的仪器设备是否经济合理；是否满足培养本科生能力培养的要求；

3.建设项目是否具备需配套的条件，如：人员、房屋及环境条件等；

4.项目建设的目标与实验室建设规划是否一致。

第十一条　立项审批的程序：

1．经教学指导专门委员会评审，提出立项建设意见；

2．学校对入库项目进行遴选、排序，经审定后上报教育部批准。

3．教务处组织申报部门，按要求将批准入围及教育部审核通过的建设项目资料信息准确填报进入项目数据库。

第五章 项目实施

第十二条　项目预算批复后，项目执行部门应按要求制定项目实施方案并编制详细的支出预算，经教务处审核、计划财务处备案后执行。

第十三条　项目执行部门应当在预算批复后1个月内，编制好符合采购要求的仪器设备购置方案，经教务处审核同意后，由国有资产管理处组织采购。

第十四条　项目执行部门严格按照合同书要求组织人员、资源实施项目建设，同时做好项目配套。实验设备到位后，按照学校国有资产管理的有关规定组织验收。

第十五条　项目实施过程中，教务处、国有资产管理处、项目执行部门共同实施监督管理。教务处负责设备采购变更审核、确认，检查、督促、协调，保

证项目顺利完成；国有资产管理处负责采购工作的组织、资产登记；项目执行部门应经常自查，检查执行情况和完成进度，协调解决实施中存在的具体问题，保证项目按计划顺利完成。

第十六条　项目执行部门严格执行项目计划和项目支出预算，不得随意变更。项目执行过程中，如发生项目变更、中止的，必须报教务处批准，根据学校批复进行调整。

第十七条　教学实验室建设项目一般要求在立项后 3 个月内执行完毕，最迟应当在当年 10 月底前全部执行完毕。

第十八条　执行单位负责项目经费支出审核，计划财务处负责项目资金预算管理。项目完成后，项目结余经费由学校调剂使用。

第六章　项目验收与绩效评价

第十九条　项目完成后，项目负责人需提交教学实验室建设项目总结报告。报告建设内容及成果、预期计划与目标的比较、项目的水平及教学应用情况、经费使用及设备验收情况、实验室尚存的问题及今后的发展计划等，申请进行项目验收。教务处组织专家对项目进行检查验收，对项目的完成情况经专家组讨论后形成书面意见与结论，并向项目组反馈意见。

第二十条　学校在教学成果评选中，设立实验室建设成果奖。

第二十一条　建设项目绩效显著，验收结果为优良的项目组成员，年终考核时应给予适当的奖励。凡项目执行不力，未能按期完成且造成不良后果的，要对项目负责人追责、问责。

第二十二条　项目的执行情况、验收结果将作为对院（系）教学工作状态评价和后期实验室建设立项的重要依据。

第七章　附则

第二十三条　本办法由教务处负责解释。

第二十四条　本办法自发文之日起实施，原《西北农林科技大学教学实验室建设项目管理办法》（校实验发〔2008〕 87 号）同时废止。

附件：西北农林科技大学教学实验室建设项目申报书

西北农林科技大学教学实验室安全管理办法（暂行）

办教发〔2016〕34号

第一章　总则

第一条　为了加强教学实验室安全管理工作，预防和杜绝安全事故，保护环境，保障师生生命和财产安全，确保实验教学工作安全顺利进行，特制定本办法。

第二条　本办法中"教学实验室"是指全校范围内开展本科实验教学工作的各类实验场所，包括国家及省部级实验教学示范中心及虚拟仿真实验教学中心等。

第三条　教学实验室安全包括易燃易爆、有毒有害、剧毒易制毒等危险化学品安全，电离与电磁辐射安全，生物安全，实验动物安全，实验废弃物安全，特种设备安全，水电及消防安全等。

第四条　教学实验室安全管理工作坚持"安全第一、预防为主、综合治理"的方针，按照"谁主管、谁负责，谁使用，谁负责"的原则，实行校院两级管理。

第二章　责任区分

第五条　教务处对全校教学实验室安全进行监督管理，负责制定教学实验室安全校级管理制度，开展教学实验室安全校级检查和督导。各学院（系、部）对本单位教学实验室安全负主体责任，负责制定本单位教学实验室安全管理制度并监督实施。

第六条　各学院（系、部）应成立教学实验室安全管理组织，定期组织开展实验室安全检查、教育、培训和宣传工作，丰富师生的安全知识，营造浓厚的实验室安全文化氛围，提高广大师生的安全意识。

第七条　教学实验室安全管理应设第一责任人、直接责任人、具体责任人，明确相应安全职责。各岗位建议职责如下：

（一）第一责任人主要职责：

1.制定本单位教学实验室安全管理制度与应急预案，并监督落实；

2.建立本单位教学实验室安全管理队伍；

3.制定本单位教学实验室安全教育和培训计划；

4.定期召开本单位教学实验室安全工作会议，听取安全工作汇报，解决院级实验室安全管理问题；

5.定期组织院级实验室安全检查，及时消除安全隐患。

（二）直接责任人主要职责：

1.全面负责所辖实验室的安全管理工作；

2.认真落实各级实验室安全管理规定，逐项审视安全预案，需要演练的，必须实战演练；

3.定期组织实验室管理员参加安全教育和培训；

4.定期和不定期巡查，指导实验室管理员做好安全工作；

5.做好所辖实验室安全管理的档案收集整理工作。

（三）具体责任人主要职责：

1.做好所负责实验室的具体安全工作，经常检查并排除所负责实验室安全隐患，并记好安全工作日志备查；

2.了解本实验室安全设施设备情况，熟练掌握安全设施设备使用操作方法，经常检查并保持设施设备完好；

3.积极参加各级组织的安全教育和培训，努力提高安全知识；

4.对进入所负责实验室的人员履行安全告知义务；

5.做好所负责实验室安全管理的登记和统计工作。

第八条　　进入教学实验室学习、工作的所有人员均对实验室安全工作和自身安全负有责任，必须遵循所在实验室各项安全管理制度，严格按照实验操作规程和实验指导书开展实验，排除安全隐患，避免事故的发生。

对于不严格遵守安全管理制度的人员，实验室安全各级责任人有权终止其使用实验室的权利。

各单位应逐步建立实验室安全工作与其他各项考评工作的直接挂钩或衔接。

第九条　　各单位应积极采取措施，层层落实教学实验室安全责任，确保横向到边、纵向到底、责任到人。

第三章　　安全检查

第十条　　教务处牵头联合相关部门对教学实验室进行定期和不定期的安全检查和督导。对存在重大安全隐患的单位，下达《实验室安全隐患整改通知书》，限期整改，对整改不力的，在全校范围内给予通报。

第十一条　　各单位应建立实验室安全检查和督导制度，实验室安全领导小组和实验室安全督导小组应切实负起责任，经常组织定期或不定期检查与督导。国家法定节假日前和每学期放假前及开学前，各单位应进行例行的安全检查，平时按照实验室安全管理规定要求进行定期和不定期检查。各单位应建立和完善实验室安全检查记录，每次检查情况均应记录备查。

第十二条　　各单位对发现的安全隐患要及时采取措施进行整改。对于存在重大安全隐患的实验室，立即封停，在隐患排除前，禁止使用。学院层面无法解决的安全隐患，应及时报学校相关部门协助解决，并积极配合做好整改工作，坚决杜绝重大事故。

第四章　　应急处置

第十三条　　如实验室发生安全事故，各单位必须按照应急预案进行应急处置，并及时将情况上报单位负责人和学校有关部门。

第十四条　　单位负责人接到事故报告后，应当迅速采取有效措施，组织抢救，防止事故扩大，减少人员伤亡和财产损失。

第十五条　　任何单位和个人不得迟报、漏报、谎报和瞒报安全事故，不得故意破坏事故现场、毁灭有关证据。

第五章　　责任追究

第十六条　　对未履行本办法中安全管理职责或安全管理执行不力的部门、单位、各级责任人以及相关管理人员，学校将按照有关规定给予严肃处理。

第十七条　　对教学实验室发生安全事故，造成人员伤亡和财产重大损失的，视情况对第一责任人、直接责任人、具体责任人及相关人员进行责任追究，触犯法律的，依法依规办理。

第六章　　附则

第十八条　　本办法自发布之日起实施。

第十九条　　本办法由教务处负责解释。

西北农林科技大学大学生学科竞赛管理办法（试行）

校教发〔2017〕115号

第一条　为培养学生的创新意识、创新精神和创新能力，鼓励和引导广大师生积极探索研究性教学，开展科研实践创新活动，特制定本办法。

第二条　大学生学科竞赛（以下简称学科竞赛）是指我校组织在校本科生、研究生参与的各级各类学科竞赛活动。

第三条　学科竞赛类别

根据学科竞赛的主办机构层级、高校参与情况和社会影响力等因素，学科竞赛分为国际级、国家级、省级和校级。

1.国际级：由国际学术团体（机构）组织的在特定学科领域具有重大国际影响力的学科竞赛；

2.国家级：由教育部或委托相关专业教学（学术）委员会组织的学科竞赛（A类）；由国家相关学术或社会机构组织的、已在全国范围内产生重大影响力的学科竞赛（B类）；

3.省级：由省教育厅及同级相关部门组织的面向高等学校学生的各类学科竞赛；

4.校级：学校设立的跨学科、学术性强、参与面广的学科竞赛，省级及以上学科竞赛的校内选拔赛。

第四条　学校成立学科竞赛领导小组，负责竞赛设置、政策制度、考核奖励等重大事项的审议与决策。组长由常务副校长担任，主管教学、学生工作的校领导任副组长，成员由教务处、研究生院、学生处、团委、就业指导中心、相关院（系、部）等单位负责人组成。

领导小组下设办公室，办公室设在教务处。

第五条　职责分工

（一）学科竞赛办公室工作职责

1.制定年度学科竞赛项目等有关文件；

2.编制学科竞赛项目经费预算；

3.审定学科竞赛项目年度执行计划，监督竞赛项目实施；

4.审核学科竞赛结果，做好考核和奖励。

（二）学院职责

1.负责年度学科竞赛项目的编制与报送；

2.负责学科竞赛实施方案制定、指导教师配备、竞赛组织实施与结果报送等；

3.负责项目经费预算与管理；

4.组织承办（参加）各级学科竞赛；

5.负责竞赛宣传、动员与总结，完成学科竞赛资料归档等。

第六条　本科生学科竞赛经费由本科教学质量工程项目预算安排，研究生学科竞赛经费由研究生创新实践活动专项预算安排。

第七条　学科竞赛经费经由学院划拨项目负责人。项目负责人按批准的资助金额编制经费使用计划，专款专用。

第八条　学科竞赛经费主要用于竞赛所需的材料费、教师指导费及与竞赛相关的其他支出等。

第九条　鼓励学院（系、部）多渠道筹措竞赛经费，提供赞助的企事业单位经学科竞赛办公室同意，可获竞赛冠名权。

第十条　教务处依据学科竞赛获奖项目的类别和数量于每年 12 月对学院进行绩效考核，对执行不力、绩效差的学院，减少下年度竞赛项目支持力度或终止项目。

第十一条　学校根据竞赛类别及获奖等级对获奖学生和指导教师分别给予奖励（奖励标准见附件），并给指导教师颁发"优秀指导教师"荣誉证书。

第十二条　获奖认定

1.以获奖证书原件或竞赛官方网站公布结果为准；

2.同年度同一竞赛项目获不同级别奖励，按最高奖励标准执行；

3.获得的金奖、银奖、铜奖按相应级别的一等奖、二等奖、三等奖认定。

第十三条　本办法自发文之日起执行。

第十四条　本办法由教务处负责解释。

2. 学院制度

（1）西北农林科技大学经济管理学院教师本科教学质量评价办法

（2）经济管理实验教学中心仪器设备损坏丢失赔偿办法

（3）经济管理实验教学中心实验材料、低值品、易耗品管理办法

（4）经济管理实验教学中心软件及技术资料管理制度

（5）经济管理实验教学中心设备维修管理制度

（6）经济管理实验教学中心基本信息收集整理及上报制度

（7）经济管理实验教学中心档案管理办法

（8）经济管理实验教学中心开放管理制度

（9）经济管理实验教学中心实验室使用管理（安全）规定（指导教师）

（10）经济管理实验教学中心实验室使用管理（安全）规定（学生）

（11）经济管理实验教学中心安全检查制度

（12）经济管理实验教学中心火灾应急预案

西北农林科技大学经济管理学院教师本科教学质量评价办法

经管〔2014〕8号

第一章　指导思想

1.完善教学质量监控体系和运行机制，切实提高教学质量。人才培养处在高校工作的中心地位，着力培养信念执著、品德优良、知识丰富、本领过硬的高素质专门人才和拔尖创新人才是高校的责任和使命，教师的教学质量是高素质人才培养质量的依托和保证。

2.教师教学质量考核旨在建立较为科学的教学质量评价体系，形成有效的考核评价机制，推进教学质量考核的规范化、制度化和科学化，进而激发和引导广大教师重视教学工作，改善教学方法，提高教学质量，同时为高校教师职称评审提供可靠的教学质量评价依据。

3.为了客观、科学地评价教师的教学质量和教学水平，促进教师不断更新教学内容和改进教学方法，提高人才培养质量，根据《教育法》和《高等教育法》等法律、法规，结合我院实际，特制定本办法。

4.作为教师，关心、爱护学生是教师的第一要义，比传授知识更为重要，学院要将此作为考评教师的重要内容，要提高教师的专业水平和教学能力。

5.对教师教学质量的评价，必须遵循教育教学规律，坚持客观、公正、公平的原则，要通过评价进一步调动教师的工作积极性，加强教风建设，促进教学改革，提高教学质量。

第二章　考核内容

1.教师的教学质量应达到教学内容充实，符合教学大纲要求；教学方式灵活，富于启发引导；授课语言生动精练、深入浅出；理论严谨、概念准确、重点突出，为教师、学生公认的教学效果优秀。

2.教师教学质量评价采取专家组听课，检查教案、课件、试卷、实验指导等教学材料和环节，并参考学生评价和学院同行评价相结合的方式进行。

3.根据听课记录和平时积累的考核记载以及被评价人本学期教学情况汇报，从教学态度、教学内容、教学方法、教学效果、教学能力、教学建设与研究等方面对教师进行评价。

4.教学建设与研究主要指教师承担的教学建设与研究情况、教学研究论文论著（教材）、教学奖励等，其中教学建设与研究情况含教学改革项目、课程建设项目、专业建设项目、教材建设项目、教学实验室建设项目、教学实习基地建设项目等

第三章　考核方式

1.学生评价，在大部分课程即将结束（通常在第十二周至第十七周）时通过网上评教进行，由学院组织学生以个人为单位对本学期任课教师进行网上评价。学生机时票和网上评教通知的发放由学院负责学生工作的老师或辅导员负责，网上评教前应向学生讲清评价的意义和要求。学生网上评教后，教师得分数据由教学办采集和处理。

2.学院同行评价，由学院领导根据平时教学管理中掌握的情况并结合期中教学检查、教师相互听课和管理人员听课所反馈的情况，集体对任课教师给出评价，于下学期开学两周内报送教学办。

3.院系评价，主要以教师的教学为中心，对教师教学过程中的思想政治方向、敬业精神、教学态度、教学纪律、教学工作量、教学任务完成状况、教学效果以及协助教学管理等方面工作作出综合性评价。

第四章　考核结果

1.评价结果分为优秀、良好、合格和不合格四个等级。

2.教学办于每学期开学四周内完成教师评价成绩的统计，写出评价分析报告，并保存相关数据和资料。

3.学院以适当方式将评价结果通知任课教师本人。

4.学院要加强学生对教师教学效果评价目的和意义的教育和引导，保证教学质量评价结果的真实性和客观性。

5.学院要对教学质量不合格的教师予以停课并提出整改要求，限期整改并参加培训。培训结束，经学院评价合格后，方可重新承担授课任务。

二〇一四年八月

经济管理实验教学中心仪器设备损坏丢失赔偿办法

一、赔偿界限

下列主观原因造成仪器设备损坏或丢失，应予赔偿。

1. 不听从指挥，违反操作规程，造成仪器设备损坏。

2. 擅自动用或拆卸仪器设备直至损坏。

3. 工作失职，指导错误，纠正不及时或保管不当造成损坏。

4. 将仪器设备携出校外造成损坏或丢失。

5. 与生活密切相关，属个人保管、使用的便携仪器造成丢失。

6. 其他由于不遵守规章制度造成的损坏与丢失。

二、赔偿处理办法

1. 低值（200元以下）仪器设备的损坏和丢失，由实验室仪器设备管理人员协助实验室主任处理赔偿事宜。根据仪器的新旧程度、丢失原因和责任大小，对直接责任人处以仪器的净值赔款。通过实验室主任批准执行。

2. 单价200元以上仪器设备的损坏和丢失，由事故所在实验室主任及仪器设备管理人员协助有关部门进行必要的调查核实（额度较大或情节严重的应及时向公安机关报案），根据仪器的新旧程度、丢失原因和责任大小，对直接责任人处以仪器的净值赔款。经分管院长批准执行。

3. 贵重仪器设备的损坏、丢失等重大事故，应先保护现场，并通知学校有关部门（保卫处、设备处等）协同处理。有关处理意见报分管院长审批。有关的文字材料报学院与设备处备案。

4. 损坏丢失的设备部件，应按新旧程度合理折算。特殊情况可按市价合理议价。

5. 对低值仪器设备中的两用（可用于生活）物品（如：照相机等）的损坏、丢失，要按原值或市价严格计价赔偿。

6. 借到家中使用的仪器设备造成丢失的，根据仪器的新旧程度、丢失原因对责任人处以仪器的净值赔款。通过实验室主任批准执行。未经批准外借的仪器设备造成损坏丢失的，不但要全额赔偿，还要追究责任人的责任。

7. 一般仪器设备损坏丢失零配件的，只计算零配件的损失价值。局部损坏可修理的，只计算修理费；损坏后质量性能明显下降，但尚能继续使用的，应按

其质量降低的程度，酌计损失价值。

8．损坏、丢失仪器设备的责任事故，属于几个人共同负责时，应根据责任大小分担赔偿。

9．赔偿工作要按确定的赔偿金额在赔偿期限内完成。对无故拖延，不执行赔偿处理决定的可以采取适当的行政措施。

经济管理学院

二〇〇二年五月三十日

经济管理实验教学中心实验材料、低值品、易耗品管理办法

第一条 为了加强我院的实验材料和低值品、易耗品的科学管理及妥善使用，防止积压浪费，保证教学、科学研究等工作的顺利进行，特制定本办法。

第二条 教学用实验材料、低值品、易耗品的经费管理，由实验室管理员根据学生人数，学科及专业特点上报至实验室主任。

第三条 教学用实验材料、低值品、易耗品，各专业实验室管理人员应根据实际需要和资金的可能，每学期第二周之前做好本学期的申购计划，经实验室主任同意后，提请分管院长批准后实施。各实验室的实验材料、低值品、易耗品包干使用经费做到专款专用。

第四条 各专业实验室管理人员依据年度计划，根据货比三家、择优选购的原则自选采购。凡一次购买批量较大实验材料、低值品、易耗品须订立经济合同。

第五条 实验材料、低值品、易耗品（以下简称物品）入库前必须认真组织验收，验收中发现问题应立即供货单位提出，及时办理退、换或赔补手续。

第六条 加强对物品的质量管理，严防损坏、变质、丢失。做到定位存放，存放有序，零整分开，帐物相符，便于收发和检查，对贵重、稀缺、危险、有毒的物品应加强集中保管，精确计量和记载，并且做到每月进行查对。

第七条 物品的领发应根据实际需要，认真核算，对常用和专用的物品可限量备用。备用物品应有专人负责保管，尽量减少浪费。

第八条 必须加强精贵稀缺和民用性强的设备管理，不得随意借出校外或私人长期占有，如发现私人长期占用和私自借出校外损坏、遗失的物品，应由经借人承担全部责任，按物品原价值赔偿。

第九条 对在用物品应建立定期抽查制度，并在每学年末全面清查一次，清查结果实验室主任备案。

第十条 对易燃、易爆、剧毒、放射性及其他危险物品，必须指定工作认真可靠并具有一定管理知识的专人加强管理，要经常对提运、使用和管理人员加强安全教育，采取必要的劳动保护与安全措施。

第十一条 危险物品的采购和提运应严格遵照公安部门和交通运输部门的有关规定办理。危险物品的保管应按照有关储存管理规定的要求设立专库，分类存放，并建立经常的安全检查制度，防止因变质、分解造成自燃和爆炸事故。

经济管理学院

二〇〇二年五月三十日

经济管理实验教学中心软件及技术资料管理制度

为加强综合实验室的管理，保证全院系统维护工作的正常开展，特制定本管理制度。

1. 综合实验室软件及技术资料包括：购置的软件及其资料、赠送的软件及其技术资料以及各种设备随带的软件和技术资料。

2. 建立软件、资料明细帐表。定期对本室的软件进行清查、核对，做到软件资料帐物卡相符，以便查阅，为教学科研服务。

3. 公共系统软件。禁止原盘外借，尤其正版软件，但可把原盘程序备份到服务器，实现内部共享。

4. 公共应用（工具）软件。禁止原盘外借，但可把原盘程序备份到服务器，实现内部共享，逐步开放共享。

5. 专业软件（带加密狗）。禁止外借，把原盘程序备份到服务器，实现内部共享。

6. 随机软件。禁止原盘外借，把原盘程序备份到服务器，实现内部共享。

7. 随机技术资料。严禁外借，要进入软件及资料明细帐表，各岗位责任人可以长期借阅，不得遗失。调出本单位时，必须还清所借资料。

8. 本制度由综合实验室软件管理员负责执行，实验室主任监督。

经济管理学院

二〇〇四年三月一日

经济管理实验教学中心设备维修管理制度

为规范综合实验室设备的维修管理，提高设备维修的透明度，严格设备维修审批程序，特制定设备维修管理制度。

1．严把设备故障的确认关。设备使用人应不断提高业务水平，对所使用的设备应做到熟练使用，对所出现的简单故障能自行解决，对于不能自行解决的故障，设备使用人应向综合实验室提出维修申请，并配合实验室人员填写维修单。

2．对于在免费保修期内的设备故障。设备使用人应及时联系实验室工作人员，由实验室负责与厂家（公司）联系。

3．对于在免费保修期外的设备故障。在维修之前，设备使用人应会同维修人员进行认真检测，然后填写设备维修卡，连同诊断结果、维修方案等一并提交综合实验室主任处。

4．对于人为造成的设备故障。该设备在管理上归属的设备领用人应责令肇事人员承担必要的维修费用及其它费用。严格执行"经济管理学院仪器设备损坏丢失赔偿办法"的原则。

5．凡是进行维修后仍无法正常使用的设备，需经主管院长签字，填写报减单后到国有资产员处登记报减。

经济管理学院

二〇〇四年三月十七日

经济管理实验教学中心基本信息收集整理及上报制度

为使我院基础教学实验室的基本信息收集、整理、上报工作科学而规范化，特制定本制度。

一、基本信息的范围及内容

1．实验室基本情况

包括实验分室编号、名称、面积、改建情况等。

2．实验教学基本信息

指实验室任务、实验大纲、实验教学计划和执行情况，以及有关实验教学的文件资料等。

3．仪器设备基本信息

仪器设备的技术资料、使用维修记录、领用消耗记录、帐和卡等文字材料。

4．人员基本信息

指实验室专职人员、兼职人员的组成、结构及变动情况。

5．其他基本信息

指有关实验室管理的各类文件、制度，实验室发展规划，工作计划及实施情况，实验研究的有关论文、成果鉴定证书，实验室经费的收支使用情况，校、院布置的临时突击性任务完成情况和事故发生的经验教训等材料。

二、基本信息的收集和整理

1．基本信息的收集整理工作，是实验室日常工作的一项重要内容。在实验室工作的专职人员，教师和研究人员有义务、有责任向信息管理人员提供有关信息资料。

2．实验室工作人员应及时填写有关各类记录，仪器设备、安全检查等表格和帐、卡，收集有关资料。

3．做好实验室专职人员工作日志记录，以利于人员考核材料的积累，认真填写实验室研究活动记录，为基本信息的收集提供更为全面的原始依据。

三、基本信息的上报及管理

实验室对基本信息必须定期进行整理统计，及时填写有关报表，按时上报，并归入实验室工作档案妥善保管。

本制度自颁布之日起实行。

经济管理学院

二〇〇五年三月一日

经济管理实验教学中心档案管理办法

实验室工作档案是实验室建设与发展的真实记载，是实验室工作的重要组成部分。为了进一步加强实验室的管理，使实验室工作逐步迈向科学化、规范化的轨道，提高办学水平及投资效益，为教学、科研服务，特制定本办法。

一、各级实验室及其主管部门要高度重视实验室工作档案的管理，必须有专人负责档案的收集、整理、汇编及存档工作。

二、实验室工作档案可分为文书档案和电子档案两种形式建立，文书档案以保存文件、资料的实物形式为基础，电子档案以保存文件、资料的电子形式为基础，实验室可根据实际工作需要及上级主管部门对实验室档案工作的要求，同时保存档案的两种形式或只保存其中某一种形式。

三、实验室文书档案收录的内容及范围包括：

1. 实验室成立的申报、论证资料，批文及各种规章制度、办法、岗位职责等文件资料；

2. 实验室发展建设规划、改革方案、实施计划、有重要价值的文件及资料；

3. 实验承担任务资料（实验教学、科研、开发与社会服务等项目的有关资料）；

4. 实验室工作人员情况（室主任、教师、实验技术人员及实验工人等）；

5. 报送上级主管部门的各种统计报表；

6. 实验室年度工作计划及总结报告；

7. 实验室经费及使用情况资料；

8. 实验室工作量统计报表及各种考核、评估、奖罚、晋升等统计资料；

9. 实验教学授课计划表及实验教学进程表；

10. 实验项目管理卡，实验教学大纲、实验教材、讲义、指导书及参考资料；

11. 近五年实验教学考试题目、成绩册及有关分析、记录资料；

12. 实验室改建情况、仪器设备修旧利废、自制改进等情况资料；

13. 实验室大型、精密、贵重仪器设备的使用、维修、保养记录；

14. 实验仪器设备等固定资产帐、卡及低值、耐用品帐目；

15. 实验室工作记录、工作日志、技安环保检查记录及承担的其它任务资料。

其中：学院及实验室编制、收录的内容为1-15条；学校职能部门编制、收录

的内容为1-5条。

四、实验室电子档案收录的内容及范围包括：

1. 实验室基本情况数据资料；

2. 实验项目数据资料；

3. 实验室专职工作人员数据资料；

4. 实验项目电子卡；

5. 实验室仪器设备数据资料；

6. 实验室其它固定资产及其重要配套设施数据资料；

7. 实验室根据实际需要所形成的其它重要电子资料。

其中：第1、2、3条按教育部规定的数据传输内容及格式建立；第4条按学校主管部门的要求建立；第5、6条按学校国有资产管理部门的要求建立；所有各条均需每年更新，如期上报。

五、实验室工作档案必须具有真实性、规范性、完整性和连续性，从实验室建立之日起开始建立档案，逐年积累，严加管理。

六、档案管理人员要高度负责，及时收集，定期整理，如有缺陷，应及时补充。要严格档案借阅手续，按规定借出，按期收回。管理人员如有变动，应及时办理移交手续。

七、实验室主任及主管部门要切实加强对档案的管理及监督检查，需要

上报的，需经实验室主任审核后，于当年12月30日前报实验室主管部门，由主管部门统一汇总上报。

八、涉及实验室工作档案的性质、保存期限、销毁等本办法未尽事宜，按《西北农林科技大学档案管理办法》有关条款执行。

九、本办法由设备处负责解释，从发布之日起执行。

经济管理学院

二〇〇五年三月一日

经济管理实验教学中心开放管理制度

实验室是高等学校实施素质教育、培养学生创新精神与实践能力的重要基地；为鼓励和支持学生在课余时间参加开放式实验教学、科研和各类社会实践活动，提高实验教学水平，促进实验教学改革，逐步形成高素质创新人才培养的新机制，规范有序地做好实验室的开放工作，特制定本办法。

一、 实验室开放的原创与意义

1． 实验室是高等学校实施素质教育、培养学生创新精神与实践能力的重要基地；实验室对学生开放、为学生提供实践学习条件是教育教学改革的重要内容。

2． 实行实验室开放是充分发挥实验室现有资源、提高仪器设备利用率的有效措施。

二、 实验室开放的形式与条件

1． 实验室开放的具体形式分为学生参与科研型实验，小发明、小制作、小论文等课外科技活动型实验。提倡学生自拟实验课题，鼓励学生参与教师课题，学习解决生产实践和科学研究问题。采用以学生为主体、教师加以启发指导的实验教学模式。

（1）学生参与科研型开放实验：主要面向高年级本科学生，应吸收部分优秀学生早期进入实验室参与科学研究活动。

（2）学生课外科技活动型开放实验：指导教师或学生自行拟定科技活动课题，结合实验室的方向和条件，参加科技活动。

（3）自拟实验课题型开放实验：学生阅读有关文献资料，确定实验方案、技术路线。鼓励学生进行创新设计实验，完成实验并撰写实验报告。

2． 本规定所指的实验室开放，应满足以下两个条件：

（1）时间的业余性：开放对学生应是业余、课外的。

（2）内容的提高性：实验的内容必须是教学计划外的，开放实验的内容难度与毕业设计课题难度相当。

三、实验室开放的组织与实施

1． 学生填写《实验室开放申请表》，向指导教师提出申请，并由指导教师审核；学生要求自带实验课题的，可向综合实验室直接提出申请，并设计好具体的实验方案，由实验室主任审核。

2．经审核后的申请表送到综合实验室，由实验室主任根据实验室情况安排具体实验时间。

3．实验室开放工作在实验室主任的统一协调下，由实验指导老师与开放实验室管理人员负责具体实施。

4．学生进入开放实验室，必须严格遵守实验室的各项规章制度。损坏仪器设备的须按制度规定进行处理。

5．学生在实验项目完成后，应向实验室提交实验报告、论文等实验结果。

6．开放实验纳入学生实验教学环节，鼓励学生利用课余时间参加开放实验室项目。

7．实验室的开放采取预约开放的形式。

8．实验项目指导教师都应根据自身条件设计一定数量的、切实可行的、具有创新意义的实验项目，并向学生公布。学生可以自由选择实验项目和指导老师。开放实验室项目的申报可每学年或每学期进行一次。

9．申请参加开放实验课题的学生原则上应是成绩优良的学生或某一方面有特长的学生。

10．鼓励和支持开放实验产生创新性成果。通过学生开放实验取得成绩的项目，可以申报各种评奖和参加比赛。

经济管理学院

二○○五年三月一日

经济管理实验教学中心实验室使用管理(安全)规定(指导教师)

一、指导教师应在在上课前五分钟到中心办公室领取实验室钥匙，带领学生进入实验室，不得迟到、早退、无故缺席。

二、督促学生严格遵守实验室的规章制度和规范操作仪器设备，爱护计算机等相关实验设备，严禁将实验室内的物品带出室外。

三、上课过程中提醒学生禁止将食品、饮料带入实验室，特别是严禁携带液体（包括水等）进入计算机实验室（房间号：C508、C601、C602、C608、A612、A613）；实验中应杜绝与上课内容无关的行为，同时保持实验室清洁卫生。

四、上课过程中应提醒学生注意安全，及时禁止在实验室内吸烟、乱动电箱以及私接、乱拉电线等行为。

五、如遇设施、设备出现故障问题时，应及时通知实验室管理人员。因违章操作引起设备的损坏要按价赔偿。

六、下课后关闭教师端电脑、中控、投影，认真填写实验室使用登记本，组织学生将垃圾带离实验室，维持实验室干净整洁、桌椅摆放整齐，关闭实验室房门后将实验室钥匙交还中心办公室。

七、指导教师需在实验（实习）课程结束后三周内完成相关数据、资料的导出工作，以便后续实验（实习）课程的正常开展。

经济管理学院

二〇一七年三月十三

经济管理实验教学中心实验室使用管理（安全）规定（学生）

一、实验室的使用应根据教学计划安排学生进行实验（实习）。学生在上实验（实习）前五分钟在指导老师带领下进入实验室上课，不得迟到、早退、缺席，不得大声喧哗。

二、严禁在实验室内玩游戏、上QQ聊天、听音乐、看电影等与上课内容无关的行为；严禁使用实验设备发布和传播危害网络安全的行为和非法言论。

三、严禁将食品、饮料带入实验室，特别是严禁携带液体（包括水等）进入计算机实验室（房间号：C508、C601、C602、C608、A612、A613），不准随地吐痰、乱抛纸屑杂物，保持实验室清洁卫生。

四、实验室内禁止吸烟；严禁乱动电箱，私接、乱拉电线及插线板。

五、上实验（实习）课严格遵守实验室的规章制度和仪器设备操作规程。爱护计算机等相关实验设备，严禁将实验室内的物品带出室外。

六、切实注意安全，如遇设施、设备出现故障问题时，应及时向指导老师报告。因违章操作引起设备的损坏要按价赔偿。

七、实验（实习）课程结束后将使用的仪器设备、桌椅等摆放整齐，恢复原位，经指导老师检查验收后，方可离开实验室。实验（实习）期间实验室使用者有义务负责打扫实验场所。

八、凡违反上述规定者，视情节轻重，给予口头警告、院级通报批评，取消全年各项评优资格等处分。情节特别严重的交学校相关部门处理。

经济管理学院

二〇一七年三月十三

经济管理实验教学中心安全检查制度

因实验室设备众多，人流密集，故实验室安全责任重大，为遏制安全隐患，结合实验室设备、环境及实验实习特点，特制定实验室安全检查制度。

一、实验室安全检查程序

1. 实验室实行每周一轮流值班进行全面安全检查，如发现不安全隐患，应及时报告各分室负责人，以便相关部门及时处理。

2. 实验室各分室负责人要对所负责管理的实验室定期进行安全检查，如发现不安全隐患，应及时排除，不能自行排除的，尽早报告有关部门处理。

二、实验室安全检查内容

1. 实验室防盗及门窗完好情况。

2. 实验室火灾隐患排查情况。

3. 实验室内消防设备是否齐备及定期更新情况。

4. 实验室电源线路是否完好。

5. 实验室安全通道是否畅通。

6. 实验室通风情况。

7. 实验室是否存在漏水问题。

8. 结合各实验分室具体情况，自检排除其它安全隐患。

经济管理学院

二〇一七年五月八日

经济管理实验教学中心火灾应急预案

一、目的

为保证经济管理实验教学中心的正常运行，对突发火灾制定应急措施，预防或减少可能产生的有害影响。

二、适用范围

本预案适用经济管理实验教学中心。

三、处理原则

1. 坚持统一领导、就地解决、分工负责、快速处理的原则。

2. 坚持尽快恢复教学安排、减少经济损失的原则。

3. 坚持原则性与灵活性相结合的原则。注意讲究策略和方法。

四、组织领导

学院设立防火领导小组：

		办公电话	手 机
组长： 王云峰	电话：	87081409	18165219360
副组长：王宇涛	电话：	87082033	13609259108
组员： 赵锦域（安全员）	电话：	87082033	13892895729
组员： 姜 硕	电话：	87082033	18192353360
组员： 任 娜	电话：	87082033	18049546220

五、火灾预案处理流程

1. 小火情

（1）首先采取自救,并及时向实验室主任汇报。

（2）根据火势的大小及引起火灾的物质性质选用水（木质类火灾）、干粉（电器火灾）、泡沫（油脂类火灾)等防火应急设备和材料投入灭火。

（3）打开灭火器上的阀门，挤压灭火器手柄，将灭火器喷嘴对准火焰底部来回挥动。

（4）如果是电源引起的火灾,首先要及时切断总电源。

（5）火势较大无法自教时,执行应急预案5.2。

2. 无法控制的火情

（1)由发现人员立即拨打119报警,详细报告发生火灾的单位、时间、地点、

原因、经过、火情、门牌号码及其它情况。与此同时，向校保卫处及学院防火领导小组报告。保卫处电话:029－87082876

（2）现场指挥人员应派人站在离火场较近的路口迎接消防队员的到来。

（3）学院火灾领导小组视火情，应及时采取相应的抢救措施，确定人员分工，可按指挥抢救、指挥灭火、指挥疏散等对到场人员进行临时性分工。若校保卫处或消防部门人员赶到现场,则学院防火领导小组配合保卫处或消防部门进行相关的灭火活动。

（4）当火情无法控制,且对现场人员生命产生极大危害时,现场指挥人员可决定仅进行现场人员疏散。

3．人员疏散

（1）学院防火领导小组应指明专人对现场不参加抢险的人员进行安全疏散。

（2）人员疏散应按照已规定好的疏散线路有序进行。

（3）对被困人员可采取下述方法进行疏导：

① 缓和救人术：当楼房火灾面积较大、受困人员较多时，可先引导、疏散受困人员到安全地点，然后再设法转移到地面。

② 架梯救人术：利用云梯、曲臂车、三节或两节梯、挂钩梯、单杠、摇梯等登高工具,架设在楼房安全位置实施抢救。

③ 绳、管救人术：利用外排水管或安全绳抢救被困人员。

④ 控制救人术：用水枪控制住楼梯、房间的火势，引导被困人员迅速冲下楼梯。

⑤ 缓降救人术：利用缓降器等消防救护设施，把被困人员疏散到地面。

⑥ 拉网救人术：可以张开救生网或衣物、棉被、帆布等铺设在地面，以供被困人员跳楼逃生。

六、职责

1．指挥部

确定启动或不启动应急预案;批准施救方案;确定现场指挥人员;负责人员、资源配置,应急队伍调动;指导协调现场有关工作;宣布解除应急状态；接受政府的指令和调动。

2．全体教职员工

减少事故损失是每位教职员工的义务和责任。所有人都必须密切配合处理突发事件，一旦接到处理突发事件的指令后，要义不容辞地快速执行。不得以任何借口推卸责任，或拒绝执行。

七、保障措施

1. 防火领导小组成员要保证移动电话和固定电话的正常使用。

2. 车队要保证交通运输车辆完好率高于90%以上。

3. 各学院绘制一份现场安全疏散阁，贴在各学院实验楼的醒目位置，自留一份，交指挥部办公室一份备用。

4. 各组成员要定期（每年至少一次)演练，不断提高现场扑救及逃生能力。

八、演练及事故总结

1. 消防演练结束后，由实验室管理处组织各学院责任人员分析演练过程，评价应急预案的合理性，必要时进一步更改应急预案的相关内容，并再次分发至各学院。

2. 如发生火灾，待火灾事故平息后，责任学院对事故原因进行调查，写出调查报告并制定整改措施，调查报告报校办一份、保卫处一份、实验室管理处一份。明确事故的责任人和处理事故过程中的立功人员。整改措施的实施情况由实验室管理处进行验证。

3. 根据学校有关管理制度规定，提出对责任人进行处分意见和对立功人员的表彰意见。

向全体师生员工通报事故经过及处分与表彰情况，让全体师生员工吸取教训，防止类似事故再次发生。

经济管理学院

二〇一八年五月二十一日

第二部分 建设成果

1. 教学成果

1.1 承担教学研究项目

表 1-1 经济管理实验教学中心成员本科教学改革研究项目

序号	项目名称	主持人	参与人
1	农林经济管理专业拔尖创新人才培养模式创新试验区	孟全省	霍学喜、姚顺波、高建中、刘海英
2	农林经济管理专业"广谱式"创新创业人才培养模式研究	赵敏娟	赵　凯、马红玉、Carol Zhang、白晓红
3	农林院校金融学专业创新　人才培养模式改革与实践	吕德宏	杜君楠、牛　荣、周慧光，杨虎锋
4	基于大数据挖掘与分析的在线教育效果评估模型研究	胡华平	朱玉春、白晓红、阮俊虎、丁吉萍
5	土地资源管理专业创新型人才培养模式研究与实践	夏显力	赵　凯、徐家鹏、晋　蓓
6	创新教学法在农林经济管理学科的实践与试点研究	贾相平	赵敏娟、石宝峰、赵珏航
7	市场营销专业人才创新能力的培养机制与教学模式优化研究	韩杏花	张晓慧、赵晓峰、包赫囡
8	农林经济管理专业核心课程教学质量评价体系建设研究	李　敏	孟全省、夏显力、王　磊
9	会计专业实践教学体系的研究与实践	雷　玲	孟全省、李民寿、张雯佳
10	体验式教学在农林经管专业实践类课程中的应用研究	刘军弟	霍学喜、刘天军、徐家鹏
11	基于创业教育理念的企业管理类课程实验教学研究与实践	王博文	郑少锋、聂　海、王宇涛
12	农林类大学会计学专业创新型人才培养模式研究	杨文杰	孔　荣、胡　频、方　丽

13	基于就业需求的实践教学体系改革与创新研究	王艳花	张晓慧、王兆华、庞晓玲
14	本科计量经济学课程教学改革研究	郭亚军	朱玉春、王永强、白秀广
15	基于创新实践平台的国际经济与贸易人才培养模式研究	邵砾群	姜志德、王秀娟、董春柳
16	工商管理专业创新型人才培养模式研究与实践——基于教师对现有大学制度和教育教学资源的重新配置的响应视角	李 桦	姚顺波、王博文、薛彩霞
17	财务管理课程研究型教学体系的研究与实践	胡 频	孔 荣、李小健、李民寿
18	MOOC环境下《现代企业管理学》微课设计研究	梁洪松	姚顺波、党红敏、李政道
19	农林经济管理专业创新教育研究	杨 峰	孙养学、张 会、陈 伟
20	农林院校金融学专业人才培养模式研究—以货币银行学为例	牛 荣	罗剑朝、崔红梅、杨虎锋
21	"做、学、教"互动模式与《国际贸易原理》课程教学模式改革研究	张 兴	王秀娟、李纪生、姜 昕
22	保险学专业的"三位一体"实践教学体系的构建研究	李 韬	聂 强、罗添元、陈 妍
23	知行并进：行动学习教学模式在农林经管专业课程中的应用研究——以《农业经济思想史》为例	刘军弟	霍学喜、张 寒、徐家鹏、闫振宇
24	基于"3S"技术的土地资源管理专业实践教学体系改革与重构	陈海滨	夏显力、晋 蓓、张道军、陈 伟
25	《发展经济学》课程多维立体教育教学模式研究	闫小欢	陆 迁、姜雅莉、汪红梅、李大垒
26	土地资源管理专业《地理信息系统》课程课堂互动教学方法研究	晋 蓓	赵 凯、李 敏、张道军、袁亚林
27	大数据背景下工商管理专业人才"核心竞争力"的培育研究	陈晓楠	姚顺波、李桦、薛彩霞、王雅楠
28	本科经济学专业博弈论实验教学设计	宋健峰	姜雅莉、汪红梅、张晓宁、石宝峰
29	面向专业大类的计量经济学案例库建设研究	王永强	朱玉春、白秀广、胡华平、阮俊虎

30	基于2014版本科人才培养方案的专业选修课质量评价与课程淘汰机制研究	董春柳	王秀娟、姜　昕、邵砾群、赵珏航
31	基于互联网的《保险学》教学模式创新研究	姬便便	罗添元、聂　强、陈　妍
32	转课堂教学模式下《林业经济学》教学内容和课程体系的设计	龚直文	高建中、骆耀峰、薛彩霞、张　寒

表 1-2 经济管理实验教学中心成员研究生教学改革研究项目

序号	项目名称	主持人	参与人
1	"研究型教学"在研究生课程教学中的建构与实施	胡　频	杨文杰、李民寿、张雯佳、崔永红
2	金融经济学英语教学精品课程建设	王　静	石宝峰、杨虎锋、姜　晗
3	应用经济类研究生拔尖创新人才培养模式研究	姜雅莉	陆　迁、汪红梅、闫小欢、张晓宁
4	公共管理学科研究生创新人才培养模式研究：以土地资源管理硕士点为例	赵　凯	李世平、余　劲、晋　蓓、陈　伟
5	会计学研究生创新培养式及实施路径选择研究	雷　玲	李民寿、张雯佳、脱潇潇、陈　悦
6	嵌入式案例分析在保险精算教学中的应用研究	罗添元	姬便便、聂　强、陈　妍
7	科研性《高级财务管理》课程改革研究	崔永红	孔　荣、孟全省、李小健、徐文娟
8	农业经济管理学术型硕士研究生培养质量控制体系建设研究——基于过程优化管理方法	刘军弟	霍学喜、闫小欢、徐家鹏、闫振宇
9	计量经济学 I（中级）	白秀广	郑少锋、王永强、胡华平、冀　昊
10	计量经济学 II（高级）	田茂茜	朱玉春、王永强、胡华平、冀　昊

表 1-3 经济管理实验教学中心成员在线课程、精品课程及优质课程

序号	课程名称	主持人	项目类别	项目级别
1	成本会计学	孟全省	MOOC 课程	国家级
2	林业经济学	张　寒	MOOC 课程	国家级
3	创新思维与创业	刘　超	MOOC 课程	国家级
4	管理学原理	张晓妮、马红玉	MOOC 课程	国家级
5	货币银行学	牛　荣	MOOC 课程	国家级
6	创业基础	汪红梅、马红玉	MOOC 课程	国家级
7	投资经济学	王　静、杨虎锋	SPOC 课程	国家级
8	国际贸易实务	邵砾群	SPOC 课程	国家级
9	成本会计学	孟全省	精品课程	省级
10	货币银行学	罗剑朝、牛　荣	精品课程	省级
11	现代企业管理学	姚顺波、李　桦	精品课程	省级
12	管理学原理	李录堂、刘　超	精品课程	校级
13	会计学原理	孔　荣	优质课程	校重点
14	计量经济学实验课	白秀广	优质课程	校重点
15	审计学	杨文杰	优质课程	校一般
16	会计综合实习II（ERP 综合实训）	李民寿	优质课程	校一般
17	国际贸易实务	邵砾群	优质课程	校一般

表 1-4 经济管理实验教学中心成员全英文课程项目

序号	课程名称	负责人	参与人
1	保险学原理	聂 强	李 韬、罗添元、陈 妍、周慧光
2	农业经济学	薛建宏	渠 美、马红玉
3	林业经济学	张 寒	骆耀峰、李 敏、刘军弟、龚直文
4	市场营销学	赵晓锋	张晓慧、庞晓玲、王兆华
5	投资经济学	王 静	石宝峰、闫小欢、杨虎锋、姜 晗
6	微观经济学（II）	赵敏娟	汪红梅、张 兴
7	计量经济学（II）	郭亚军	胡华平
8	发展经济学	薛建宏	张 兴
9	高级财务管理学	孔 荣	郑少锋、孟全省、徐文娟
10	投资经济与项目管理	刘天军	王永强、刘军弟
11	资源与环境经济学	赵 凯	赵敏娟、李世平、姚顺波、夏显力、陈海滨

表 1-5 经济管理实验教学中心成员实验课程建设项目

序号	项目名称	主持人	参与人
1	财务管理	崔永红	孔 荣、孟全省、胡 频、张雯佳、徐文娟
2	营销策划	王 谊	韩 樱、王兆华、王艳花、张晓慧、庞晓玲、任 娜
3	市场营销学	庞晓玲	张晓慧、王艳花、王 谊、赵晓锋、任 娜
4	现代企业管理	梁洪松	刘 超、薛彩霞、王宇涛
5	市场调研	赵晓锋	张晓慧、韩杏花、王艳花、王兆华、吕淑杰、赵锦域
6	创业管理	马红玉	赵敏娟、徐家鹏、邱 璐、赵锦域
7	时间序列分析	杨虎锋	石宝峰、王宇涛、姜 晗
8	商业银行经营管理	胡 振	任 娜、杨虎锋
9	保险精算学	罗添元	聂 强、陈 妍、王宇涛、姜 硕

10	保险学原理	聂　强	罗添元、陈　妍、王宇涛、姜　硕
11	国际结算	董春柳	邵砾群、王宇涛
12	国际贸易实务	邵砾群	董春柳、姜志德、王秀娟、王宇涛、姜　昕
13	博弈论	宋健峰	陈晓楠、姜雅莉、石宝峰、任　娜
14	数理经济学	赵殷钰	郭亚军
15	计量经济学	冀　昊	丁吉萍、阮俊虎、胡华平、王宇涛
16	统计学原理	胡华平	胡华平、白秀广、丁吉萍、冀　昊
17	教学实习 II	崔红梅	罗剑朝、吕德宏、牛　荣、石宝峰、崔红梅、杨虎锋、王宇涛
18	风险管理学	杨　峰	杨　峰、高建中、王宇涛、李大垒、张　会、陈伟
19	农产品贸易与政策	张　寒	王宇涛、徐家鹏、李　敏、邵砾群、闫振宇
20	房地产开发与经营	张　会	张　会、南　灵、钱　冬、姚　岚、任　娜
21	土地利用规划	夏显力	陈　伟、张道军、姚　岚
22	土地利用工程与规划设计	张道军	陈　伟、任　娜

表 1-6 经济管理实验教学中心成员"课程思政"示范课程项目

序号	课程名称	项目负责人	团队成员
1	金融工程	王　静	石宝峰、杨虎锋、姜　晗
2	货币银行学	牛　荣	杜君楠、崔红梅、杨虎峰、姜　晗
3	国际贸易原理	董春柳	王秀娟、邵砾群、姜　昕、李纪生
4	产业经济学	张晓宁	姜雅莉、宋健峰
5	管理学原理	梁洪松	李　桦、刘　超、张晓妮、王雅楠
6	管理信息系统	党红敏	李　桦、薛彩霞、李政道
7	市场营销学	王兆华	王艳花、王　谊、庞晓玲、吕淑杰
8	组织行为学	李　敏	马红玉、高建中、徐家鹏、刘军弟
9	村镇建设规划	张蚌蚌	陈　伟
10	地图学与计算机制图	晋　蓓	陈海滨、张道军、候现慧

表 1-7 经济管理实验教学中心成员指导的大学生创新训练计划项目

序号	指导教师	项目名称	项目级别	项目负责人	立项时间
1	胡华平	资金筹措利用能力与农贸市场个体商贩成长研究——基于社会关系网络视角的实证分析	国家级	郭　静	2016 年
2	张晓宁	宅基地退出补偿政策对农民工进城买房意愿影响研究——以西安地区为例	国家级	金桢栋	2016 年
3	马红玉	"互联网+"背景下新生代农民工创业行为研究——以陕西省关中地区为例	国家级	辛颖志	2016 年
4	孙养学	基于主粮化战略的马铃薯产业链延伸研究——以陕西省榆林地区为例	国家级	左怡忱	2016 年
5	龚直文	太白山自然保护区农户生物多样性保护生态补偿研究——基于选择实验法	国家级	季金林	2017 年
6	薛彩霞	咸阳市精准扶贫模式及其效果研究：基于可持续生计框架视角	国家级	马泽蓉	2017 年
7	刘天军	互联网+背景下农户认知对其安全生产行为的影响	国家级	张朝凯	2017 年
8	赵晓锋	粮食主产区规模经营对粮农种粮意愿的影响效应研究	国家级	陈　倩	2017 年
9	郭亚军	基于乡村振兴战略视阈下的西安市农村土地流转模式研究——以高陵区为例	国家级	郭晨浩	2018 年
10	董春柳	基于 CVM 法的农户生活垃圾源头分类受偿意愿分析——以陕西省 20 个美丽乡村标准化试点为例	国家级	曹啸林	2018 年
11	刘天军	人际信任、制度信任与农民就业决策	国家级	马　橙	2018 年
12	胡华平	农户电子商务边缘性参与行为研究——基于陕西鲜果种销户的实证分析	国家级	张天然	2018 年
13	李世平	农户土地价值观念对耕地质量保护的影响	国家级	宁思银	2018 年
14	孔　荣	收入结构、合同信任与农户标准化生产履约行为——以洛川苹果种植户为例	国家级	井　睿	2019 年
15	阮俊虎	设施蔬菜种植户参与物联网电商的意愿研究——以陕西省为例	国家级	梁玉虎	2019 年

16	董春柳	金融素养对生物资产抵押融资意愿的影响路径与实证研究——基于陕西试点地区家庭农场微观数据	国家级	袁峥嵘	2019 年
17	徐家鹏	女性化、社会网络与猕猴桃种植户绿色生产技术采纳行为——基于陕西省的微观调研数据	国家级	葛俊良	2019 年
18	李 桦	农户绿色生产意愿与行为的悖离研究——以陕西关中地区樱桃种植户农药使用为例	国家级	罗 岚	2019 年
19	牛 荣	"合作社+农户"利益机制构建研究——以陕西省周至县为例	国家级	孟 真	2019 年
20	马红玉	人居环境治理绩效及其影响因素分析	国家级	吴溪溪	2019 年
21	李政道	高校食堂如何在高峰期提高就餐效率——以物联网和流水线技术分析	省级	卢 卓	2016 年
22	骆耀峰	林农对互联网苗木信息的需求及采纳度的影响分析	省级	王 帅	2016 年
23	聂 强	陕西省城镇居民保险逆向选择问题研究	省级	邢菀祯	2017 年
24	牛 荣	基于不同经营类型的农地承包经营权抵押贷款需求研究——以陕西省典型地区为例	省级	杜瑞瑞	2017 年
25	聂 强	农业产业化视角下"农超对接"收益分配问题——以周至县为例	省级	姬文哲	2017 年
26	阮俊虎	农产品电商对农户收入的影响机制研究：以陕西省武功县农户调研数据为例	省级	朱柯燕	2017 年
27	孟全省	对杨凌示范区"扶贫超市"模式的绩效研究	省级	张长月	2017 年
28	杨 峰	陕西省集体林权制度配套改革对农户林业收入的影响研究	省级	朱嘉林	2017 年
29	徐家鹏	陕南地区农村劳动力迁移下留守老人多维贫困：测度、分解及扶贫对策	省级	马明义	2018 年
30	李世平	新常态下农户土地流转对其信贷可得性的影响 ——以关中地区为例	省级	卫丽君	2018 年
31	孔 荣	心理账户对农民商业保险购买行为的影响研究	省级	袁熙文	2018 年
32	阮俊虎	电商环境下农户购入新型鲜果运输保险的影响因素以及支付意愿研究——以陕西省猕猴桃产业为例	省级	于 浩	2018 年

33	张道军	基于规模、效益与意愿的县域休耕时空布局研究——以宁夏回族自治区海原县为例	省级	康鼎荣	2019 年
34	马红玉	精准扶贫背景下农村人力资本投资对农户收入的影响——以丹凤县为例	省级	于倩聿	2019 年
35	宋健峰	供求双侧视角下农户金融排斥测度与根源分析——基于 Oaxaca-Blinder 分解	省级	胡昊东	2019 年
36	陈 伟	网络购物对农民消费结构的影响研究——基于近郊与远郊村庄的比较	省级	姚佳静	2019 年
37	杨虎峰	家庭农场信贷可得性的规模歧视研究	省级	国子轩	2019 年
38	白秀广	农民居住地变迁视角下农村宅基地有偿退出模式研究及影响因素	省级	刘家玮	2019 年
39	白秀广	粮食生产的化肥利用效率空间差异及影响因素研究——基于空间 Durbin 模型的实证分析	省级	张天问	2019 年
40	马红玉	人情消费与农村居民生活质量关系研究-以陕西省为例	省级	吴南南	2019 年
41	杨 峰	基于兼业分化视角下农户休耕受偿意愿及补贴标准研究——以甘肃省会宁县为例	省级	张 清	2019 年
42	赵敏娟	西部农户家庭多维贫困测度与精准扶贫优先序研究——以陕西省国家重点生态功能区为例	省级	杨小芳	2019 年
43	孟全省	农户小额信用贷款增信方式调查与比较研究——以杨凌农业高新技术产业示范区为例	校重点	蒋承祚	2015 年
44	陈 伟	关中地区农用地流转对农户福利影响的调查研究	校重点	刘雪婷	2015 年
45	阮俊虎	鲜果电商物流模式调研与分析——以周至、眉县猕猴桃为例	校重点	任亚琴	2015 年
46	聂 强	周至县猕猴桃保险推广的影响因素研究	校重点	唐发林	2015 年
47	崔永红	行政村财务管理组织体系研究	校重点	许佳佳	2015 年
48	胡华平	消费者对生鲜果蔬的产地和时节的认知与购买行为差异	校重点	陈晓晓	2015 年
49	淮建军	农户买租玉米脱粒机意愿影响因素的研究——基于 logistic 模型	校重点	朱 洁	2015 年

50	马红玉	农村土地增值收益分配模式调查研究	校重点	王露宇	2015 年
51	孟全省	陕西省关中地区农村宅基地退出影响因素分析	校重点	王 亚	2015 年
52	骆耀峰	少数民族农户对气候变化的响应与适应能力的研究——以云南哈尼族为例	校重点	朱舒宁	2016 年
53	杨文杰	农村社区突发事件的应急管理研究	校重点	王 聪	2016 年
54	丁吉萍	现代农产品销售创新模式研究：以陕西省户县葡萄为例	校重点	马 建	2016 年
55	李世平	农村土地承包经营权流转纠纷及其化解	校重点	丁 翔	2016 年
56	胡华平	农产品电商集聚效应与成长的研究——基于武功县的实证研究	校重点	张尚怡	2017 年
57	李世平	农地承包经营权抵押对农户信贷约束的影响——以陕北地区为例	校重点	马晓隆	2017 年
58	孔 荣	乡村旅游同质化测度及差异化发展对策研究——一陕西省泾阳县茯茶小镇为例	校重点	王雅婷	2017 年
59	董春柳	老年农户农地承包权退出意愿影响因素研究	校重点	沈金龙	2018 年
60	张 寒	生态环境的贫困效应研究——基于陕西省县级面板数据的门槛回归分析	校重点	王 吟	2018 年
61	孔 荣	城市居民金融素养、投资偏好与农业众筹参与意愿研究——以陕西地级市为例	校重点	李静榕	2018 年
62	王礼力	农民专业合作社组建联合社的行为研究——以陕西省苹果农民专业合作社为例	校重点	薛凯芸	2018 年
63	阮俊虎	鲜果电商消费者购买强度和购买强度调整行为研究——基于西安市碑林区雁塔区调研数据为例	校重点	王锴昊	2018 年
64	张 寒	乡村民宿旅游对于当地居民收入水平与收入结构的影响研究——基于浙江省莫干山，西坑村，茅洋乡文山村等地的调研	校重点	崔 涛	2019 年
65	李 桦	农户绿色生产意识和行为一致性研究——以西乡县"汉中仙毫"为例	校重点	郭丁豪	2019 年
66	牛 荣	农户金融意识及其借贷选择比较研究——以贫困与非贫困地区为例	校重点	井昀琦	2019 年

67	孟全省	新型农业经营主体对智慧农业发展意愿研究——以杨凌农业高新技术产业示范区为例	校重点	徐 铭	2019 年
68	徐家鹏	城镇化进程中农村家庭女性就业对配偶创业选择与收入的影响	校重点	何江梦	2019 年
69	阮俊虎	社会资本、网络信任与农户短视频营销效益——以周至县、眉县猕猴桃产业为例	校重点	余 炎	2019 年
70	刘天军	社会网络对苹果种植户安全生产行为影响的机理与路径研究——以农药施用为例	校重点	胡佳瑞	2019 年
71	骆耀峰	乡村振兴战略下农户异质性对种植业碳效率的影响研究	校重点	徐明庆	2019 年
72	牛 荣	农户参与农民专业合作社的行为机理分析——以陕西省杨凌示范区为例	校重点	刘益溦	2019 年
73	梁洪松	城乡二元结构下城市与农村留守儿童幸福感影响因素对比分析——以杨陵和西安为例	校重点	杨 茜	2019 年
74	李录堂 田茂茜	乡村振兴背景下，"城镇工商资本下乡"过程中的发展条件研究	校重点	田镕恺	2019 年
75	崔永红	关于杨凌示范区农村合作社农产品商品化影响因素的研究	校一般	王亚利	2015 年
76	胡华平	媒体曝光的非对称影响——消费者对生鲜农产品购买态度与行为的比较研究	校一般	李康莉	2015 年
77	晋 蓓	基于遥感影像的杨凌区居民点空间分布形态研究	校一般	李文轩	2015 年
78	李民寿	陕西省关中地区城镇化对农户收入及消费结构影响	校一般	苍耀东	2015 年
79	孟全省	农民住房反向抵押贷款养老模式的探究	校一般	王心怡	2015 年
80	宋健峰	农户水资源反弹效应的实验经济学研究	校一般	魏 昕	2015 年
81	王永强	烟草税的提高对烟民烟草消费的影响	校一般	李云燕	2015 年
82	杨虎峰	农村生活垃圾产生现状及治理研究-杨陵区为例	校一般	张伊凡	2015 年
83	杨虎峰	本科生专业满意度的比较分析——基于学生转专业动机的调查	校一般	童微乔	2015 年

表 1-8 经济管理实验教学中心成员指导的大学生创业训练计划项目

序号	指导教师	项目名称	项目级别	项目负责人	立项时间
1	陈 龙 邵砾群	"Thunder"神经酸能量棒——解决脑部亚健康问题的曙光	国家级	姚玉婷	2019 年
2	刘 超	果墅	国家级	王鑫歌	2019 年
3	王铁成 马红玉	"纯源"新型家用净水器	省级	田锦萱	2019 年
4	马红玉	圾乐净土	省级	李 维	2019 年
5	宋健峰	江山无刺多椒——无刺花椒新品种及产品推广	省级	田歆宁	2019 年
6	马红玉	"曙光薯农"对口帮扶	省级	刘 爽	2019 年
7	马红玉	共享经济下共享书店建设	校一般	吴溪溪	2018 年
8	李 桦	M·T 托雷特有限责任公司	校一般	王翔宇	2018 年
9	李 桦	R.BOOK——西农二手书交易社交 APP	校一般	王 珍	2018 年
10	郭亚军	G 公社	校一般	刘彦冰	2018 年
11	李大垒	西农特产研发推广	校一般	黄若晴	2019 年
12	庞晓玲 曹 宁 李侃侃	心情便利贴——大学生心语心愿 APP	校一般	韦彩娇	2019 年

1.2 中心获奖及证书

表 1-9 经济管理实验教学中心教学成果奖

序号	奖励名称	获奖项目名称	完成人	获奖年度	获奖等级	授奖单位
1	教学成果奖	农林经济管理专业人才创新能力培养模式的研究与实践	孟全省 霍学喜 姚顺波 高建中 刘海英	2012	一等奖	陕西省人民政府
2	教学成果奖	经济管理类专业实践教学质量保障体系的建设与实践	孟全省 孔 荣 吕德宏 夏显力 王秀娟	2009	二等奖	陕西省人民政府
3	教学成果奖	"校企合作、实践育人"的实践教学模式	姚顺波 孔 荣 李 华 李民寿 刘海英	2013	二等奖	西北农林科技大学
4	教学成果奖	职业能力指导下会计学专业立体化实习模式的探索与实践	胡 频 孟全省 孔 荣 杨文杰 李民寿	2013	二等奖	西北农林科技大学
5	教学成果奖	农林院校金融学专业创新人才培养模式改革与实践	吕德宏 包赫囵 牛 荣 姬便便 杨虎锋	2015	二等奖	西北农林科技大学
6	教学成果奖	国际经济与贸易专业实践教学创新平台的构建与实践	邵砾群 姜志德 王秀娟 董春柳 李纪生	2015	二等奖	西北农林科技大学
7	大学生学科竞赛成果奖	第八届全国大学生电子商务"创新、创意及创	王秀娟 马 橙	2018	二等奖	第八届全国大学生电子

		业"挑战赛	张婉婷 贾一琦 肖涵予 林澍青			商务"创新、创意及创业"挑战赛陕西省竞赛组织委员会
8	大学生学科竞赛成果奖	"学创杯"2019全国大学生创业综合模拟大赛	党红敏 吴 豪 李 跃 杨学静	2019	二等奖	高等学校国家级实验教学示范中心联席会经管学科组
9	大学生学科竞赛成果奖	"寻找中国管理与信息化三好学生"暨第八届"用友新道杯"全国大学生会计信息化技能大赛	李民寿 王宇涛 王清清 张秦月 张 越 高 敏	2014	一等奖	工业和信息化部人才交流中心 用友新道科技有限公司
10	大学生学科竞赛成果奖	第九届"新道杯"全国大学生会计信息化技能大赛陕西省总决赛	李民寿 王宇涛 赛 骞 戴君华 李翠伟 张秋梦 曹晓彤	2015	一等奖	陕西省高等教育学会、陕西省职业技术教育学会、新道科技股份有限公司
11	大学生学科竞赛成果奖	第三届全国大学生人力资源管理知识技能竞赛	刘 超 梁洪松 常心爱 左艺辉 王若琦 任丽君	2018	二等奖	中国人力资源开发研究会

教 学 成 果 奖

证 书

成果名称： 农林经济管理专业人才创
新能力培养模式的研究与
实践

获奖等级： 一等奖

完 成 人： 孟全省 霍学喜 姚顺波
高建中 刘海英

获奖单位： 西北农林科技大学

编号：SJX111011-1

二〇一二年一月四日

教 学 成 果 奖

证 书

成果名称： 经济管理类专业实践教
学质量保障体系的建设
与实践

获奖等级： 二等奖

完 成 人： 孟全省　孔　荣　吕德宏
夏显力　王秀娟

获奖单位： 西北农林科技大学

编号：SJX092065-1

二〇〇九年十月十五日

西北农林科技大学
NORTHWEST A&F UNIVERSITY

成果名称："校企合作、实践育人"的实践教学模式

获奖等级：二等奖

主要完成人：姚顺波 孔荣 李桦 李民寿 刘海英

证书编号：CG201219

2012年教学成果奖

获奖证书

二〇一三年一月十七日

西北农林科技大学
NORTHWEST A&F UNIVERSITY

成果名称：职业能力导向下会计学专业立体化
实习模式的探索与实践

获奖等级：二等奖

主要完成人：胡颊 孟全省 孔荣 杨文杰 李民寿

证书编号：CG201240

2012年教学成果奖

获奖证书

二〇一三年一月十七日

西北农林科技大学
NORTHWEST A&F UNIVERSITY

2015年教学成果奖获奖证书

成果名称：农林院校金融学专业创新人才培养模式改革与实践

获奖等级：贰等奖

主要完成人：吕德宏 包赫囡 牛荣 姬便便 杨虎锋

证书编号：CG201514

二〇一六年一月十九日

西北农林科技大学
NORTHWEST A&F UNIVERSITY

2015年教学成果奖获奖证书

成果名称：国际经济与贸易专业实践教学创新平台的构建与实践

获奖等级：贰等奖

主要完成人：邵砾群 姜志德 王秀娟 董春柳 李纪生

证书编号：CG201522

二〇一六年一月十九日

荣誉证书
HONORARY CREDENTIAL

小设计在第八届全国大学生电子商务"创新、创意及创业"挑战赛陕西赛区选拔赛中荣获二等奖。

特发此证，以资鼓励。

团队成员：马橙 张婉婷 贾一琦 肖涵予 林澍青

指导教师：王秀娟

陕西省竞赛组织委员会

二〇一八年七月

获奖证书
CERTIFICATE

西北农林科技大学：

获得"学创杯"2019全国大学生创业综合模拟大赛省赛二等奖。
Won the second prize in the provincial College Student Entrepreneurship Comprehensive Simulation Competition of 2019 Learning Entrepreneurship Cup.

团队成员：吴豪 李跃 杨学静

指导老师：党红敏

特发此证，以兹鼓励。
Specially issued this certificate to encourage.

高等学校国家级实验教学示范中心联席会经管学科组

二〇一九年五月

寻找中国管理与信息化三好生

暨第八届"用友新道杯"全国大学生会计信息化技能大赛

西北农林科技大学一队代表队 王清清、张素月、张越、高敏 同学

在由工业和信息化部人才交流中心、用友新道科技有限公司联合主办，全国高等学校学生信息咨询与就业指导中心支持的"寻找中国管理与信息化三好生"暨第八届"用友新道杯"全国大学生会计信息化技能大赛 陕西省总决赛（本科组）中荣获 一等奖 。

特发此证，以兹鼓励！

工业和信息化部人才交流中心   用友新道科技有限公司

2014年11月

寻找中国管理与信息化三好生

暨第八届"用友新道杯"全国大学生会计信息化技能大赛

王宇涛 老师

在由工业和信息化部人才交流中心、用友新道科技有限公司联合主办，全国高等学校学生信息咨询与就业指导中心支持的"寻找中国管理与信息化三好生"暨第八届"用友新道杯"全国大学生会计信息化技能大赛 全国决赛（本科组）中荣获 一等奖 。

特发此证，以兹鼓励！

工业和信息化部人才交流中心   用友新道科技有限公司

2014年11月

第九届 "新道杯"
全国大学生会计信息化技能大赛

西北农林科技大学 第一 代表队

在由陕西省教育厅指导，陕西省高等教育学会、陕西省职业技术教育学会主办的第九届
"新道杯"全国大学生会计信息化技能大赛 陕西省总决赛 中荣获 一等奖
特发此证，以兹鼓励！

团队成员：赛骞、戴君华、李翠伟、张秋梦、曹晓彤

陕西省高等教育学会　　　陕西省职业技术教育学会　　　新道科技股份有限公司
2015年12月

第九届 "新道杯"
全国大学生会计信息化技能大赛

西北农林科技大学

在由陕西省教育厅指导，陕西省高等教育学会、陕西省职业技术教育学会主办的
第九届 "新道杯" 全国大学生会计信息化技能大赛 陕西省总决赛
团体奖 中荣获 一等奖
特发此证，以兹鼓励！

陕西省高等教育学会　　　陕西省职业技术教育学会　　　新道科技股份有限公司
2015年12月

全国大学生人力资源管理知识技能竞赛

荣誉证书

西北农林科技大学 代表队：

在由中国人力资源开发研究会知识技能竞赛理事会主办、宝鸡文理学院承办的**第三届全国大学生人力资源管理知识技能竞赛（精创教育杯）第七大区赛**（甘肃、宁夏、青海、陕西、西藏、新疆）中荣获二等奖。

特发此证，以兹鼓励！

中国人力资源开发研究会
知识技能竞赛理事会
二〇一八年六月
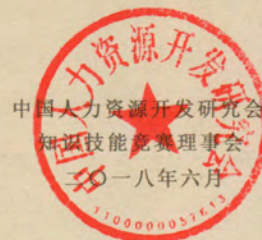
全国大学生人力资源管理知识技能竞赛

荣 誉 证 书

梁洪松 老师：

您在由中国人力资源开发研究会知识技能竞赛理事会主办、宝鸡文理学院承办的**第三届全国大学生人力资源管理知识技能竞赛（精创教育杯）第七大区赛**（甘肃、宁夏、青海、陕西、西藏、新疆）中带领团队荣获佳绩，被评为优秀指导老师。

特发此证，以兹鼓励！

中国人力资源开发研究会
知识技能竞赛理事会
二〇一八年六月

表 1-10 经济管理实验教学中心成员获奖

序号	姓名	获奖名称	时间（年）	授奖单位
1	孟全省	省级教学名师	2015	陕西省教育厅
2	张 寒	陕西省首届高校课堂教学创新大赛二等奖	2018	陕西省教育厅
3	李政道	陕西高等学校第四届青年教师教学竞赛二等奖	2018	陕西省教育厅
4	孟全省	宝钢优秀教师奖	2018	宝钢教育基金会
5	马红玉	教育部农经教指委《农业经济学》讲课比赛一等奖	2019	教育部农经教指委
6	孟全省	校级教学标兵	2014	西北农林科技大学
7	王秀娟	校级优秀教师	2014	西北农林科技大学
8	孟全省	校级优秀教师	2015	西北农林科技大学
9	李政道	校级优秀教师	2017	西北农林科技大学
10	张 寒	校级优秀教师	2018	西北农林科技大学
11	党红敏	校青年教师讲课比赛三等奖	2014	西北农林科技大学
12	张 寒	校青年教师讲课比赛三等奖	2014	西北农林科技大学
13	张 寒	校首届微课比赛教学风采奖	2015	西北农林科技大学
14	张 寒	校首届微课教学比赛三等奖	2015	西北农林科技大学
15	党红敏	校青年教师讲课比赛三等奖	2016	西北农林科技大学
16	李政道	校青年教师讲课比赛二等奖	2017	西北农林科技大学
17	丁吉萍	校青年教师讲课比赛三等奖	2017	西北农林科技大学
18	张 寒	校青年教师讲课比赛二等奖	2018	西北农林科技大学
19	赵敏娟	校级科研先进个人	2015	西北农林科技大学
20	李 桦	校级科研先进个人	2015	西北农林科技大学
21	李世平	校级科研先进个人	2017	西北农林科技大学

22	李　桦	校级科研先进个人	2018	西北农林科技大学
23	李　桦	思政先进个人	2013	西北农林科技大学
24	董春柳	思政先进个人	2013	西北农林科技大学
25	王兆华	思政先进个人	2014	西北农林科技大学
26	牛　荣	思政先进个人	2015	西北农林科技大学
27	马红玉	思政先进个人	2015	西北农林科技大学
28	王秀娟	思政先进个人	2015	西北农林科技大学
29	董春柳	思政先进个人	2016	西北农林科技大学
30	郭亚军	思政先进个人	2016	西北农林科技大学
31	张　寒	校师德师风先进个人	2018	西北农林科技大学
32	王兆华	校师德师风先进个人	2018	西北农林科技大学

荣誉证书

孟全省同志

被评为第九届陕西省高等学校教学
名师，特发此证

陕西省教育厅
二O一五年六月三十日

荣誉证书

CERTIFICATE OF HONOR

张寒 同志：

荣获陕西首届高校课堂教学创新大赛**二等奖**，特颁此证。

中共陕西省委教育工委　　陕西省教育厅
二〇一八年十二月

荣誉证书

李政道同志：

在陕西高等学校第四届青年教师教学竞赛中，荣获二等奖（文科组）。

特发此证

陕西省教育厅　陕西省教科文卫体工会委员会
2018年7月16日

宝钢教育奖证书

孟全省 老师荣获二〇一八年度

宝钢优秀教师奖。特颁此证。

学校　西北农林科技大学

宝钢教育基金会理事长

宝字第 201810244 号

2018 年 11 月

荣誉证书

孟全省 同志被评为西北农林

科技大学 2014 年度教学标兵。

特发此证。

中共西北农林科技大学委员会
西北农林科技大学
二〇一五年二月二十七日

荣誉证书

孟全省 同志被评为西北农林科技大学 2015 年度优秀教师。

特发此证。

中共西北农林科技大学委员会
西北农林科技大学
二〇一六年三月一日

荣誉证书

李政道 同志被评为西北农林科技大学 2017 年度优秀教师。

特发此证。

中共西北农林科技大学委员会
西北农林科技大学
二〇一八年二月二十七日

荣誉证书

张寒 同志被评为西北农林科技大学 2018 年度优秀教师。
特发此证。

中共西北农林科技大学委员会
西 北 农 林 科 技 大 学
二〇一九年二月二十七日

荣誉证书
HONORARY CREDENTIAL

张 寒 同志荣获 2014 年度
青年教师讲课比赛 三 等奖。
特发此证，以资鼓励。

西北农林科技大学
二〇一五年一月九日

荣 誉 证 书

张 寒 同志获西北农林科技大学首届微课教学比赛 教学风采奖。

特发此证，以资鼓励。

西北农林科技大学
二〇一五年四月十五日

荣 誉 证 书

张 寒 同志获西北农林科技大学首届微课教学比赛三等奖。

特发此证，以资鼓励。

西北农林科技大学
二〇一五年四月十五日

荣 誉 证 书

党红敏同志荣获2016年

青年教师讲课比赛 三等奖。

特发此证，以资鼓励。

西北农林科技大学

2017年1月5日

荣誉证书

李政道同志荣获2017年青年教师讲课比赛**二等奖**。特发此证，以资鼓励。

西北农林科技大学
2017年12月29日

荣誉证书

丁吉萍同志荣获2017年青年教师讲课比赛三等奖。特发此证，以资鼓励。

西北农林科技大学

2017年12月29日

荣誉证书

HONOR CERTIFICATE

张 寒

在 2018 年青年教师讲

课比赛中荣获

二等奖

特发此证，以资鼓励。

西北农林科技大学

2019年1月20日

西北农林科技大学

荣 誉 证 书

王兆华 同志被评为2018年度

"大学生思想政治教育先进个人"，

特发此证，以资鼓励。

西北农林科技大学
思想政治教育工作领导小组（代章）
2019年1月

西北农林科技大学

荣誉证书

授予：张　寒老师

"2018年度西北农林科技大学师德先进个人"荣誉称号

中共西北农林科技大学委员会
二〇一九年三月

西北农林科技大学

荣誉证书

授予：王兆华老师

"2018年度西北农林科技大学师德
先进个人"荣誉称号

中共西北农林科技大学委员会
二〇一九年三月

表 1-11 经济管理实验教学中心成员指导的本科生校级

"百篇优秀毕业论文（设计）"

序号	论文（设计）题目	指导教师	学生	时间
1	社会网络对农户融资渠道选择的影响研究——以宁夏平罗县为例	胡 振	刘泽元	2019年
2	风险投资对P2P网贷平台绩效影响研究	杨虎锋	李 含	2019年
3	基于消费者认知与人际特征视阈下的第三方信息影响消费决策研究——以鲜果电商购买为例	张晓宁	王锠昊	2019年
4	鲜果电商消费者购买行为影响因素及行为识别	阮俊虎	应新安	2019年
5	农民兼业、社会网络与安全生产行为	刘天军	朱嘉林	2019年
6	环境认知、环保责任感对农户绿色生产行为的影响研究——基于陕西省583户苹果种植户的数据分析	张 寒	张婉婷	2019年
7	农户土地价值观念对耕地质量保护行为的影响研究——基于关中地区农户调研资料	李世平	吴 爽	2019年
8	基于植被恢复潜力实现视角的生态工程实施效果评价——以延安市为例	张道军	徐 鑫	2019年
9	资源型城市工业用地利用效率时空演变及驱动因素研究	陈 伟	陈文君	2019年
10	移动社区用户感知价值、沉浸体验对用户粘性的影响——以网易云音乐为例	韩 樱	刘金华	2018年
11	中国对美国果蔬产品出口三元边际及影响因素分析	董春柳	吴鑫桐	2018年
12	共享经济下的信用评价反馈与用户持续消费分析——基于网约车资产状况和消费者社会关系视角	胡华平	包 彤	2018年
13	我国上市公司治理结构对盈余管理的影响分析	李民寿	全泽宁	2018年
14	PPP模式下中国生态环境保护投资效率评价研究	骆耀峰	李 薇	2018年
15	金融知识与家庭储蓄率—基于金融市场参与中介效应的实证研究	赵敏娟	金桢栋	2018年
16	"一带一路"背景下中国与东盟农产品贸易影响因素及贸易潜力研究——基于贸易引力模型的分析	张 寒	王 奇	2018年
17	基于差异驱动的江苏省开发区土地集约利用综合评价研究	陈 伟	季静文	2018年
18	土地配置视角下地价对化工业集聚的时空影响研究	陈海滨	王 倩	2018年
19	时空视角下延安市生态政策对植被恢复的影响研究	张道军	贾琦琪	2018年

荣誉证书

刘泽元 同学完成的本科毕业论文《社会网络对农户融资渠道选择的影响研究—以宁夏平罗县为例》被评为 2019 届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学
教务处
二〇一九年六月二十日

荣誉证书

李 含 同学完成的本科毕业论文《风险投资对P2P网贷平台绩效影响研究》被评为2019届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学
教务处
二〇一九年六月二十日

荣誉证书

王锟昊　同学完成的本科毕业论文《基于消费者认知与人际特征视阈下的第三方信息影响消费决策研究—以鲜果电商购买为例》被评为 2019 届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学
教务处
二〇一九年六月二十日

荣誉证书

应新安 同学完成的本科毕业论文《鲜果电商消费者购买行为影响因素及行为识别》被评为 2019 届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学

教务处

二〇一九年六月二十日

荣誉证书

朱嘉林 同学完成的本科毕业论文《农民兼业、社会网络与安全生产行为》被评为 2019 届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学

教务处

二〇一九年六月二十日

荣誉证书

张婉婷 同学完成的本科毕业论文《环境认知、环保责任感对农户绿色生产行为的影响研究—基于陕西省583户苹果种植户的数据分析》被评为2019届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学
教 务 处
二O一九年六月二十日

荣誉证书

吴 爽 同学完成的本科毕业论文《农户土地价值观念对耕地质量保护行为的影响研究——基于关中地区农户调研资料》被评为 2019 届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学

教 务 处

二〇一九年六月二十日

荣誉证书

徐 鑫 同学完成的本科毕业论文《基于植被恢复潜力实现视角的生态工程实施效果评价——以延安市为例》被评为 2019 届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学
教务处
二〇一九年六月二十日

荣誉证书

陈文君 同学完成的本科毕业论文《资源型城市工业用地利用效率时空演变及驱动因素研究》被评为2019届本科"百篇优秀毕业论文（设计）"。

特发此证

西北农林科技大学

教务处

二〇一九年六月二十日

1.3 主编教材

表 1-12 经济管理实验教学中心成员主编实验教材

序号	教材名称	字数（千字）	出版社	出版时间	主编	备注
1	会计信息系统实验教材	180	西北农林科技大学出版社	2018.12	李民寿	
2	国贸实务实训教材	230	西北农林科技大学出版社	2018.12	邵砾群	
3	市场营销实验教材	240	西北农林科技大学出版社	2018.12	庞晓玲	
4	财务管理计算机模拟实验教程	200	西北农林科技大学出版社	2018.12	崔永红	
5	地理信息系统软件ArcGIS10应用教程	340	西北农林科技大学出版社	2018.12	晋 蓓	
6	《运筹学》实验指导书	23		2015	李政道	自编
7	《统计学原理》实验指导书	24		2015	数量经济教研室	自编
8	《计量经济学》实验指导书	27		2015	数量经济教研室	自编
9	《保险学原理》实验指导书	109		2016	李 韬	自编
10	《博弈论》实验指导书	68		2016	《博弈论》教学团队	自编
11	《风险管理学》实验指导书	75		2016	杨 峰	自编
12	《证券投资技术分析》实验指导书	43		2017	杨虎锋	自编
13	《时间序列分析》实验指导书	65		2017	杨虎锋	自编
14	《农业技术经济学》实验指导书	137		2017	徐家鹏	自编
15	土地资源调查实习指导书	80		2018	张 会	自编

表 1-13 经济管理实验教学中心成员主编理论教材

序号	教材名称	字数（千字）	出版社	出版时间	主编
1	农产品营销	148	三秦出版社	2014.03	王秀娟
2	现代企业管理学	450	科学出版社	2015.03	姚顺波 李 桦
3	管理学基础	430	武汉大学出版社	2015.06	梁洪松（副主编）
4	会计学基础（第三版）	398	中国农业出版社	2015.08	孟全省
5	会计学教程	435	西安电子科技大学出版社	2016.01	孟全省
6	农产品市场营销实务	300	西北农林科技大学出版社	2017.01	刘 超
7	成本会计学	493	中国农业出版社	2018.05	孟全省

会计信息系统
实验教程：

用友ERP—U8 V10.1版

■ 李民寿　王宇涛　主编

西北农林科技大学出版社

会计信息系统实验教程：用友ERP—U8 V10.1版

李民寿　王宇涛　主编

国际贸易实务

实验教程

邵砾群　主编

西北农林科技大学出版社

国际贸易实务实验教程

邵砾群 主编

西北农林科技大学出版社

市场营销实验教程

庞晓玲　主编

西北农林科技大学出版社

市场营销实验教程

庞晓玲 主编

财务管理

计算机模拟实验教程

崔永红　主编

西北农林科技大学出版社

财务管理计算机模拟实验教程

崔永红 主编

地理信息系统软件
ArcGIS10

应用教程

晋　蓓　黄明珂　主编

西北农林科技大学出版社

地理信息系统软件ArcGIS10应用教程

晋　蓓　黄明珂　主编

《运筹学》
实验指导书

注：本内容参考自

1　熊伟编著，《运筹学》（第三版），机械工业出版社，2015

2　西安交通大学管理学院运筹学课程组编写，《运筹学实验指导书》，2007

WinQSB 软件

WinQSB 是《运筹学》应用软件包 QSB+的升级应用软件包，运行在 Windows 环境下，操作方便，非常适合初学者上机使用。

第一章　WinQSB 的基本内容

WinQSB 应用软件包可求解如下 19 类问题：

序号	程　序	缩写、文件名	名称	应用范围
1	Acceptance Sampling Analysis	ASA	接受抽样分析	各种抽样分析、抽样方案设计、假设分析
2	Aggregate Planning	AP	综合计划编制	具有多时期正常、加班、分时、转包生产量，需求量，储存费用，生产费用等复杂的整体综合生产计划的编制方法。将问题归结到求解线性规划模型或运输模型。
3	decision analysis	DA	决策分析	确定型与风险型决策、贝叶斯决策、决策树、二人零和对策、蒙特卡罗模拟。
4	Dynamic Programming	DP	动态规划	最短路问题、背包问题、生产与储存问题
5	Facility Location and Layout	FLL	设备场地布局	设备场地设计、功能布局、线路均衡布局
6	Forecasting and Linear Regression	FC	预测与线性回归	简单平均、移动平均、加权移动平均、线性趋势移动平均、指数平滑、多元线性回归、Holt-Winters 季节迭加与乘积算法
7	Goal Programming	GP—IGP	目标规划	多目标线性规划、线性目标规划，变量可以取整、连续、0—1 或无限制
8	Inventory Theory and Systems	ITS	存储论与存储系统	经济订货批量、批量折扣、单时期随机模型，多时期动态储存模型，储存控制系统（各种储存策略）
9	Job Scheduling	JOB	作业调度	机器加工排序、流水线车间加工排序。
10	Linear and Integer programming	LP—ILP	线性规划与整数规划	线性规划、整数规划、写对偶、灵敏度分析、参数分析
11	MarKov Process	MKP	马耳科夫过程	
12	Material requirements planning	MRP	物料需求计划	
13	Network Modeling	Net	网络模型	运输、指派、最大流、最短路、最小支撑树、货

《统计学原理》

实验指导书

数量经济教研室

统计学原理

模块一：课程导论

一、学习目标

知识目标：使学生掌握统计学基本原理与方法，为专业课程（如财会、金融、管理等课程）的学习奠定基础。

能力目标：使学生掌握基本调查方法及组织形式，指导学生科学地搜集整理资料、进行论文设计和撰写，初步掌握 Excel 的基本统计整理和分析功能。

二、学习任务描述

本项目的学习主要学习统计学基本原理和统计工作过程，运用多种统计分析方法如综合指标法、时间数列法、统计指数法、抽样推断法、相关与回归分析法等，对各种理论和实际问题进行分析。主要任务描述如下：

了解：统计调查的种类、统计整理的内容、组织形式；总量指标的分类及表现形式；动态数列的种类、构成因素、测定方法；指数的分类、指数数列内容；抽样调查的作用、概念及基本原理；简单线性相关与简单回归分析的一般程序。

掌握：统计调查方案内容及统计调查问卷基本结构；统计分组的基本理论与方法；时期指标和时点指标异同、相对指标的对比关系；平均指标和速度指标的计算方法、应用条件及有关指标的相互关系；综合指数和平均指数的编制方法；平均误差、极限误差的原理和计算；简单线性相关分析和一元线性回归分析的理论与方法。

重点掌握：统计指标设计的一般问题；根据某一实际问题设计统计调查方案和拟定统计调查问卷；依据实际资料进行统计分组，编制分布数列和统计表；相对指标、平均指标、变异指标计算方法和应用原则；同度量的固定时期、根据实际资料构建数量指标指数和质量指标指数体系、并进行因素分析；对所研究的事物整体及其特征进行综合分析；具体运用简单线性相关和一元线性回归的方法进行分析和预测。

三、学习任务分析

任务一：统计调查与整理。本部分讲述的中心问题就是怎样组织统计调查，才能为统计整理和统计分析提供准确、及时、全面、系统的统计资料。要求学生明确统计调查种类，弄清制定统计调查方案的必要性和步骤，掌握普查、重点调查、抽样调查、典型调查的特点，掌握变量数列的编制和图表分析。

任务二：综合指标。本部分着重讲述总量指标、相对指标和变异指标的意义、种类、计算和应用。要求学生必须掌握各项统计指标的概念、特点和作用，熟悉各种统计指标的计算方法，重点把握平均指标和标志变异指标的基本理论和计算方法，领会各种平均数的特点、

《计量经济学》

实验指导书

数量经济教研室

计量经济学实验课—EVIEWS软件

一、 实验说明

针对目前我院《计量经济学》本科教学注重课堂上理论讲授，而忽视软件操作实际应用的现状，及结合 2014 版《本科教学新大纲》的增加《计量经济学》实验课程的要求，希望以此为契机，将《计量经济学实验课程》打造成优质课程，使学生能够理论联系实际，熟练运用相关软件解决现实问题。

本实验主要是计量经济学理论的实践，引导学生掌握利用 EVIEWS 计量软件进行计量分析的方法和步骤，并要求对软件运行结果进行解释。本实验涉及到的计量分析主要包括简单线性回归模型与多元线性回归模型，EVIEWS 在检验多重共线性、异方差和序列相关中的应用，EVIEWS 在分布滞后模型、含有虚拟变量的模型、联立方程模型的估计以及模型本身的识别与检验等十大模块，并最终有学生根据自身兴趣完成一个完整的实验案例并进行分析，以起到学以致用的效果。

二、 实验

实验一 EVIEWS软件简介

实验目的及要求

本实验主要对 EVIEWS 软件进行简单的介绍，学会运用软件进行基本的统计分析。能熟练运用EVIEWS 软件建立工作文件，对时间序列数据进行基本操作。

实验内容及步骤

(一) EVIEWS 9.0软件的安装(略)

(二) EVIEWS操作过程

下面通过一个简单的回归分析例子使学生先对Eviews有个概括了解。以安徽省苹果种植面积变动为例。实验步骤为：

表2-1 1984-2012年安徽苹果种植面积（千公顷）

年份	安徽苹果面积（千公顷）	年份	安徽苹果面积（千公顷）
1984	7.9	1999	24.7
1985	8.0	2000	23.6
1986	14.1	2001	20.7
1987	20.2	2002	17.9
1988	25.9	2003	17.1
1989	25.3	2004	16.1
1990	25.5	2005	13.9
1991	24.3	2006	13.4
1992	24.4	2007	13.3

1

《保险学原理》实验指导书

学院专业：经济管理学院金融学专业

学生班级：金融 143-144

实验时间：2016 年秋

指导教师：李韬

2016 年 8 月

浙科保险实务模拟教学软件
实验操作指导手册
目录

1

《博弈论》
实验指导手册

《博弈论》教学团队

目录

风险管理学
实验指导书

编著：杨峰

西北农林科技大学经济管理学院

目　录

1

《证券投资技术分析》
实验指导书

学　　院：　经济管理学院

教 研 室：　金融学教研室

教师姓名：　杨虎锋

2017 年

目　录

《时间序列分析》
实验指导书

学　　院：　经济管理学院

教 研 室：　金融学教研室

教师姓名：　杨虎锋

2017 年

《时间序列分析》实验指导书

目　录

《农业技术经济学》

实验指导书

徐家鹏

经济管理学院

目录

土地资源调查

实习指导书

■ 张 会 主编

农产品市场营销

主 编：王秀娟

农 产 品 市 场 营 销

王秀娟　主编

现代企业管理学

（第三版）

姚顺波　主编

前　言

《现代企业管理学(第三版)》编委会

主　　编　姚顺波

副主编　李　桦　王博文

编　者　（按姓氏拼音排序）

　　　　陈晓楠　党红敏　高建忠　李政道　梁洪松

　　　　刘　超　刘春梅　薛彩霞　杨和财　张晓妮

主　　审　郑少锋

内 容 简 介

本书是西北农林科技大学"高等教育面向 21 世纪教学内容和课程体系改革计划"及"网络环境下现代企业管理学多媒体课程建设"的研究成果，同时也是省级精品课程配套教材。全书突破传统企业管理教材框架，分原理篇和应用篇进行论述。力求加强基础理论教学，增强学生适应社会的能力；并瞄准企业管理学发展前沿，充分体现现代企业管理内涵。

本书可作为理、工、农、医、文、法等非管理专业高等院校经济管理基础课教材，也可供在职干部进行企业管理知识培训使用。

管理学基础

GUAN LI XUE JI CHU

刘云鹏 雷 达 廖彩霞◎主编

Wuhan University Press
武汉大学出版社

管理学基础

主　编　刘云鹏　雷　达　廖彩霞

副主编　梁洪松　薛　丽　许　燕

李朝良　王冲冲

参　编　李子珍

（以上排名不分先后）

会计学基础

第三版

KUAIJIXUE JICHU

● 孟全省　刘麦荣　主编

会计学教程

主编　孟全省

内容简介

本书深入浅出地介绍了会计学的基本知识和原理。全书共分为9个模块，内容包括会计学科导论、成本会计专题、管理会计专题、财务管理专题、审计专题、高级财务会计专题、税法专题、会计电算化专题和会计研究专题。

本书结构合理，内容流畅，通俗易懂，可作为广大中等职业学校会计教师的培训教材，也可供高职高专院校选用。

NONGCHANPIN
SHICHANG YINGXIAO SHIWU

农产品

市场营销实务

项目牵头单位　　西北农林科技大学
项目负责人　　王　雄
主　编　　刘　超　庞晓玲
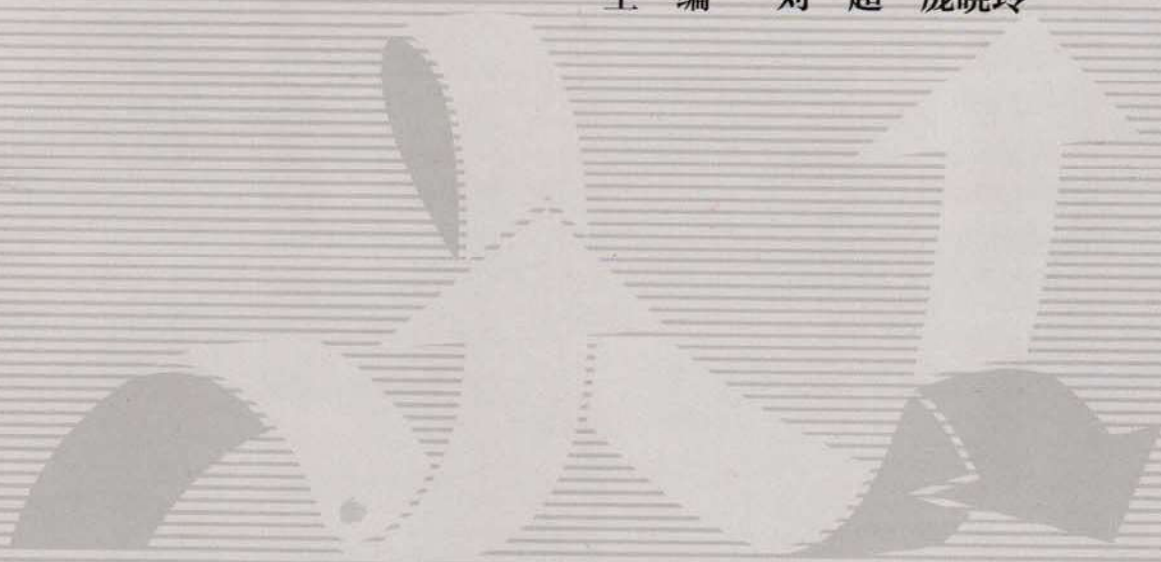
农产品市场营销实务

刘　超　庞晓玲　主编

普通高等教育农业部"十三五"规划教材

成本会计

COST ACCOUNTING

孟全省◎主编

生产费用的核算、产品成本计算的基本方法、产品成本计算的辅助方法、农业产品成本的核算、
其他传统行业成本核算、新兴行业的成本核算、成本报表、成本分析、成本会计前沿

中国农业出版社

1.4 发表教改论文

表 1-14 经济管理实验教学中心成员发表教改论文

序号	论文名称	期刊名称	年份、期刊卷次	第一作者	期刊等级
1	管理类专业信息化应用型人才"三维一体"实践教学运行模式研究	高教论坛	2013.10	李 桦	B类
2	高校"本科教学工程"实施效果分析——基于 6所农林高校学生认可视角问卷调查	中国农业教育	2013.12	李 桦	B类
3	基于"学、拓、化"架构下的计量经济学教学模式探索	高教论坛	2013.11	郭亚军	B类
4	基于二元Logistic 模型的文科实验室环境建设对大学生技能提升的作用研究	实验室研究与探索	2013.11	王宇涛	B类
5	高等农林院校金融专业人才培养模式探讨	黑龙江教育（高教研究与评估）	2013.11	姬便便	B类
6	大学生就业期望与实际签约情况比较研究——西北农林科技大学2012届本科毕业生为例	中国农业教育	2013.02	马红玉	B类
7	ERP沙盘模拟教学对工商管理专业学生能力培养的效果分析	高教论坛	2013.10	薛彩霞	B类
8	适应就业需求的农林经济管理专业人才培养机制研究—以西北农林科技大学为例	中国林业教育	2015.01	马红玉	B类
9	基于六次产业理念胜任素质冰山模型的农业职业经理人培育研究	中国农业教育	2018.08	薛彩霞	B类
10	大学生领导力培养与建设研究	教育教学论坛	2015.11	邵砾群	公开
11	农业院校经济学专业毕业论文的非农选题研究	福建广播电视大学学报	2015.03	李大垒	公开
12	高校会计模拟实验实践教学满意度调查分析——基于创新人才培养模式视角	高教学刊	2015.05	雷 玲	公开

13	ERP实习满意度实证分析——以某高等农林院校为例	高教学刊	2015.06	雷　玲	公开
14	基于SWOT分析的陕西高校微课模式设计研究	社会科学前沿	2016.02	梁洪松	公开
15	互联网经济背景下的产业经济学教学改革与实践探索	当代经济	2016.27	张晓宁	公开
16	信息经济下的产业变革与产业经济学教学改革探索	中小企业管理与科技	2016 .12	张晓宁	公开
17	高校实验技术人员综合素质培养的探索	实验室科学	2016 .04	赵锦域	公开
18	经济学专业本科毕业论文质量问题与对策	高教论坛	2017.09	李大垒	公开
19	专创融合的教育理念与实践：基于综合型人才培养的视角	高教学刊	2017.16	杨　峰	公开
20	高校双创教育理念及其体系构建	教育教学论坛	2018.04	杨　峰	公开

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——以西北农林科技大学经济管理学院实践教学模式为例

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：高素质信息化应用型人才受到越来越多企业的青睐。本研究基于西北农林科技大学经济管理学院"三维一体"的信息化应用实践教学模式，阐述信息化应用型人才"三维一体"实践教学运行模式的构成、运作、特点、应用效果及其建议，旨在为当前多数高校在信息化应用型人才培养方面提出思路和对策。

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4.72%、6.02%

14.74%,

71.15%、74.39%、75.41%

77.37%,

表1

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	2010	2011	2012	2013
非常认可	46.14%	48.32%	51.23%	58.78%
基本认可	25.01%	26.07%	24.18%	18.59%
未定	12.70%	9.50%	13.20%	9.40%
基本不认可	6.15%	6.31%	3.10%	6.11%
非常不认可	10.00%	9.80%	8.29%	7.12%
合计	100%	100%	100%	100%

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3.30%、4.26%　10.60%,

75.15%、78.39%、82.41%　88.37%,

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表2

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	2010	2011	2012	2013
非常认可	66.14%	68.32%	71.23%	78.78%
基本认可	9.01%	10.07%	11.18%	9.59%
未定	9.16%	9.31%	8.20%	5.38%
基本不认可	5.35%	5.50%	3.10%	2.13%
非常不认可	10.34%	6.80%	6.29%	4.12%
合计	100%	100%	100%	100%

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4.68%、11.07%　7.75%,

75.14%、78.33%、82.77%　87.92%,

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	2010	2011	2012	2013
非常认可	64.11%	67.11%	74.54%	80.32%
基本认可	11.03%	11.22%	8.23%	7.60%
未定	8.16%	9.11%	7.78%	5.83%
基本不认可	6.10%	5.76%	3.29%	3.07%
非常不认可	10.60%	6.80%	6.16%	3.18%
合计	100%	100%	100%	100%

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Study on the Operation Mode of Three－Dimensional Practice Teaching

——Based on the Case of the Practice Teaching Mode of the College of Economic Management in Northwest A&F University

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Abstract：High quality talent with the ability mastering enterprise information system application technology are now being welcomed by more and more modern enterprise. Based on the case of the practice teaching mode of the three－dimensional practice teaching of the College of Economic Management in Northwest A&F University,the paper expounds the constitution,operation,feature ,and application effect of the mode in order to show its application way to lots of universities.

Key Words：personnel with mastering information technology;three－dimensional practice teaching;cooperation between colleges and enterprises

Taking Employment as Orientation to Build Extra－curricular Education Front for Practical Writing Course in Higher Vocational Education

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Abstract：Practical writing ability is a core skill required for modern workers. During higher vocational teaching reform,since social activity is transformed into courses,the reform of practical writing course should take employment as orientation to make comprehensive and meticulous designs for extra－curricular activity of practical writing teaching. Through buiding platforms for reading communication,writing guidance and writing competition,students' cultural deposits can be enriched,colleges' features of serving the society can be highlighted,the competition characteristics of vocational education can be demonstrated,and students' comprehensive quality can be improved overally.

Key Words：higher vocational education;practical writing;extra－curricular education;front

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高校"本科教学工程"实施效果分析
——基于6所农林高校学生认可视角问卷调查

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（西北农林科技大学，陕西 杨凌 712100）

[摘　要]为考察"本科教学质量与教学改革工程"7年来的实施效果，课题组对6所不同类型的农林高校学生进行问卷调查。统计结果显示：由于"本科教学工程"给教师提供了更多的"走出去"提升教学科研能力的机会，多数学生高度认可教师在课程设计、课堂教学环节方面的提升效果，但在专业培养目标的明确性，教材的时效与创新性，实习或实验提升就业科研能力等方面的改进没有得到多数学生的认可，最终导致学生对该项工程实施效果的总体评价偏低。

[关键词]农林高校；本科教学工程；实施效果

[中图分类号]G642　　　　[文献标识码]B　　　[文献编号]1009-1173（2013）06-0083-05

自上世纪90年代末开始，我国高等教育快速进入大众化阶段[1]。回顾这一历程不难发现诸多问题，其中，引起社会普遍关注的问题之一就是高等教育质量的下滑[2]。为解决这一问题，从2007年1月起，我国高等院校正式全面实施了"高等教育本科教育质量与教学改革工程"（以下简称"本科教学工程"），这是继"211工程"、"985工程"和"国家示范性高等职业院校建设计划"之后，我国在高等教育领域实施的又一项重要工程，总体看来取得了一定成效[3]。历经7年，"本科教学工程"的实施效果如何，存在什么问题，如何改进？本文就此对6所农林高校的学生进行问卷调查分析，以期为政府部门推进"本科教学工程"提供对策建议。

一、调查方法、对象与内容

（一）调查方法与对象

本研究主要采用问卷调查法来搜集所需要的信息。问卷的设计力求全面、客观地反映"本科教学质量评价体系"的建设成效及其存在的问题。调查对象为2所"985"高校和4所省属高校的在校大学生，并按随机抽样原则进行面对面的问答式调查。

（二）调查内容与问卷回收情况

调查问卷围绕"本科教学工程"中"本科教学质量评价体系"设置的内容，包括专业定位与培养目标、课堂教学环节（开课备课、课堂教学、教师答疑、作业批改、考试阅卷、成绩登录等）、实验环节、实习环节、课程设计环节等19个问项。问项采用Likert五分量表，即1表示"非常不认可"，2表示"基本不认可"，3表示未定，4表示"基本认可"，5表示"非常认可"。本次调查，每所学校发放问卷90份，共450份，回收有效问卷"985"高校为135份，省属高校为295份，合计430份，问卷有效回收率为95.56%。

二、问卷调查结果统计描述和分析

为了比较全面地了解7年来"本科教学工程"实施状况，本文从学生对专业培养目标评价、教师选用教材评价、教师课程设计评价、教学课堂环节评价、教学实践或实习环节评价、"本科教学工程"总体评价等6方面进行分类统计与分析，具体统计结果见表1至表6。

（一）学生对专业培养目标的评价

从表1统计结果看，42.32%的学生认为学院的专业培养目标非常明确，其中"985"高校有37.41%

的学生对其认可,省属高校有 47.23% 的学生对其认可。依据五分量表,学生对学院的专业培养目标的总体评价得分为 3.15 分,表明学生对专业培养目标明确性认可度较低,由此可以看出,高校尤其是"985"高校在专业培养目标方面不够明确,应尽快依据社会人才需求进行进一步清晰化和定位。

表 1　学生对专业培养目标评价

实施指标		总体	985 高校	省属高校
专业培养目标非常明确	认可	42.32%	37.41%	47.23%
	未定	31.07%	25.56%	36.58%
	不认可	26.61%	37.03%	16.19%
	得分	3.15(0.21)	3.00(0.23)	3.31(0.31)

注:得分一栏括号里的数字是依据五分量计算的标准差(下同)

(二)学生对教师选用教材环节的评价

教材质量总体上可以从国内外优秀教材选用和教材是否具有时效性创新性两方面来概括。从表 2 统计结果可以看出,一是有 43.73% 的学生认可授课教师选用国内外优秀教材,其中"985"高校有 47.14% 的学生对其认可,省属高校有 40.32% 的学生对其认可。依据五分量表,学生对其认可评价得分为 3.34 分,表明学生对授课教师选用国内外优秀教材认可度较低;二是有 30.38% 学生认可授课教师选用教材的时效性、创新性,其中"985"高校有 48.41% 的学生对其认可,省属高校有 12.35% 的学生对其认可。依据五分量表,学生对对其认可评价得分为 3.01 分,表明教师选用教材的时效性、创新性差。由以上两方面可以看出,目前我国高校尤其是省属高校在教材方面仍需及时更新和甄选,以期教师、学生能紧跟该学科领域的前沿和了解社会实际需求。

表 2　学生对教师选用教材质量方面的评价

实施指标		总体	985 高校	省属高校
国内外优秀教材	认可	43.73%	47.14%	40.32%
	未定	35.25%	38.94%	31.56%
	不认可	21.02%	13.92%	28.12%
	得分	3.34(0.52)	3.49(0.61)	3.18(0.45)
教材的时效性、创新性	认可	30.38%	48.41%	12.35%
	未定	40.31%	46.23%	34.39%
	不认可	29.31%	5.36%	53.26%
	得分	3.01(0.25)	3.65(0.43)	2.39(0.21)

(三)学生对教师课程设计环节的评价

学生对教师课程设计方面的评价可以从课程目标、课程内容安排、教师授课准备和教师知识储备四方面来反映。从表 3 统计结果看出,一是有 68.80% 学生认可教师所授课程目标清晰度,其中"985"高校有 67.12% 的学生对其认可,省属高校有 70.47% 的学生对其认可。依据五分量表,学生对其认可的总体得分为 3.79 分,表明学生对课程目标清晰度基本认可。二是有 52.67% 学生认可教师所授课程内容新颖、系统,其中"985"高校有 57.23% 的学生对其表示认可,省属高校有 48.11% 的学生对其表示认可。依据五分量表,学生对其认可得分为 3.39 分,表明学生对课程内容新颖、系统认可不是很高。三是有 73.10% 的学生认可教师授课准备充分,其中"985"高校有 77.87% 的学生对其表示认可,省属高校有 68.32% 的学生对其表示认可。依据五分量表,学生对其认可得分为 3.67 分,表明学生对教师授课准备充分认可度为接近基本认可。四是有 58.83% 学生认可教师知识储备扎实,其中"985"高校有 64.41% 的学生对其表示认可,省属高校有 53.25% 的学生对其表示认可。依据五分量表,学生对其认可得分为 3.51 分,表明学生对教师授课准备充分达到了基本认可。

表 3　学生对教师课程设计方面的评价

实施指标		总体	985 高校	省属高校
课程目标非常清晰	认可	68.80%	67.12%	70.47%
	未定	15.18%	18.37%	11.98%
	不认可	16.03%	14.51%	17.55%
	得分	3.79(0.65)	3.79(0.45)	3.80(0.14)
课程内容新颖、系统	认可	52.67%	57.23%	48.11%
	未定	33.91%	36.58%	31.23%
	不认可	13.43%	6.19%	20.66%
	得分	3.39(0.53)	3.59(0.71)	3.27(0.46)
教师授课准备充分	认可	73.10%	77.87%	68.32%
	未定	21.13%	18.58%	23.67%
	不认可	5.77%	3.53%	8.01%
	得分	3.67(0.51)	3.89(0.48)	3.64(0.45)
教师知识储备扎实	认可	58.83%	64.41%	53.25%
	未定	33.72%	31.76%	35.68%
	不认可	7.45%	3.83%	11.07%
	得分	3.51(0.43)	3.80(0.55)	3.45(0.47)

由以上四方面可以得出,目前我国高校有 50% 以上的学生对教师课程设计环节的认可度基本上达到了 3.5 分;同时也表明,尽管"985"高校在这方面相对优于省属高校,但离 4 分基本认可或 5

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分非常认可还有较大差距，这指明了高校在促进"本科教学工程"中的努力方向，以及学校如何完善对教师的激励导向性机制。

（四）学生对课堂教学环节的评价

学生对教师课堂教学环节方面的评价可以从教师的教学方法、教学形式、课堂气氛、教师对提问题答疑以及作业布置与讲解等五方面来反映。从表4统计结果看，一是有62.77%学生认可教师采用教学方法的有效性，其中"985"高校有72.86%的学生对其表示认可，省属高校有52.68%的学生对其表示认可。依据五分量表，学生对其认可得分为3.90分，表明学生对教师采用教学方法的有效性达到了基本认可。二是有52.83%学生认可教师鼓励学生积极参与课堂教学形式，其中"985"高校有55.21%的学生对其表示认可，省属高校有50.44%的学生对其表示认可。依据五分量表，学生对其认可得分为3.71分，表明学生对教师采用教学方法的有效性认可度较高。三是有38.15%学生认可课堂气氛很活跃，其中"985"高校有30.97%的学生对其表示认可，省高校有45.32%的学生对其表示认可。依据五分量表，学生对其认可得分为

3.27分，表明学生对课堂气氛很活跃的认可度较低。四是有66.82%的学生认可教师对提出的问题及时回复，其中"985"高校有72.40%的学生对其表示认可，省属高校有61.23%的学生对其表示认可。依据五分量表，学生对其认可得分为3.92分，表明学生对教师对所提问题及时回复认可度较高。五是有49.05%学生认可教师及时布置与讲解作业，其中"985"高校有54.23%的学生对其表示认可，省属高校有43.87%的学生表示对其认可。依据五分量表，学生对其认可得分为3.61分，表明学生对教师对提出的问题及时回复认可度比较高。

由以上五方面可以看出，目前我国高校有50%以上的学生对教师课程设计环节的认可度基本上达到了3.5分以上，总体上"985"高校在这方面优于省属高校，但离4分基本认可或5分非常认可还有不少差距，这表明了高校教师以后在这方面仍需"以学生为本"改进课堂教学环节，进一步分解与巩固教学内容，而学校应持续完善教师教学投入机制。

（五）学生对教学实践或实习环节的评价

学生对教学实践或实习环节方面的评价可以从实践实习与课堂教学内容结合程度、提升综合实践能力、培养协作意识、提升就业能力以及提升科研创新能力等五方面来反映。

从表5统计结果看出，一是有70.01%学生认可教学实践或实习环节与课堂教学内容紧密结合，其中"985"高校有68.32%的学生对其表示认可，省属高校有71.70%的学生对其表示认可。依据五分量表，学生对对其认可得分为3.90分，表明学生对教学实践或实习环节与课堂教学内容紧密程度认可度较高。二是有63.16%学生认可教学实践或实习环节能提升综合实践能力，其中"985"高校有64.51%的学生对其表示认可，省属高校有61.81%的学生对其表示认可。依据五分量表，学生对其认可得分为3.85分，表明学生对教学实践或实习环节能提升综合实践能力认可度较高。三是有54.80%的学生认可教学实践或实习环节能培养协作意识，其中"985"高校有60.20%的学生对其表示认可，省属高校有49.40%的学生对其表示认可。依据五分量表，学生对教学实践或实习环节培养协作意识总体评价得分为3.71分，表明学生对教学实践或实习环节培养协作意识认可度较高。四是有71.80%学生认可教学实践或实习环节能提升就业能力，其中"985"高校有66.70%的学生对其表示认可，省属高校有76.90%的

表 4　学生对教师课堂教学环节方面的评价

实施指标		总体	985高校	省属高校
教师采用教学方法有效	认可	62.77%	72.86%	52.68%
	未定	30.05%	23.89%	36.21%
	不认可	7.18%	3.25%	11.11%
	得分	3.90(0.45)	4.21(0.61)	3.49(0.38)
鼓励学生积极参与课堂教学形式	认可	52.83%	55.21%	50.44%
	未定	41.37%	42.33%	40.41%
	不认可	5.81%	2.46%	9.15%
	得分	3.71(0.64)	3.79(0.74)	3.62(0.69)
课堂气氛很活跃	认可	38.15%	30.97%	45.32%
	未定	41.99%	52.21%	31.76%
	不认可	19.87%	16.81%	22.92%
	得分	3.27(0.66)	3.21(0.70)	3.34(0.67)
教师对提出的问题及时回复	认可	66.82%	72.40%	61.23%
	未定	27.54%	24.04%	31.04%
	不认可	5.65%	3.56%	7.73%
	得分	3.92(0.58)	4.03(0.60)	3.80(0.61)
教师及时布置与讲解作业	认可	49.05%	54.23%	43.87%
	未定	42.50%	37.57%	47.42%
	不认可	8.46%	8.2%	8.71%
	得分	3.61(0.54)	3.69(0.57)	3.53(0.55)

学生对其表示认可。依据五分量表,学生对教学实践或实习环节能提升就业能力认可得分为 3.96 分,表明学生对教师教学实践或实习环节提升就业能力认可度很高。五是有 27.88% 的学生认可教学实践或实习环节能提升创新或科研能力,其中"985"高校有 32.39% 的学生对其表示认可,省属高校 23.37% 的学生对其表示认可。依据五分量表,学生对其认可得分为 2.97 分,表明学生对教师教学实践或实习环节能提升创新或科研能力认可度很低。

表 5 学生对教学实践或实习环节方面的评价

实施指标		总体	985 高校	省属高校
教学实践或实习环节与课堂教学内容紧密结合	认可	70.01%	68.32%	71.70%
	未定	20.28%	18.32%	22.23%
	不认可	9.72%	13.36%	6.07%
	得分	3.90(0.41)	3.82(0.25)	3.98(0.34)
教学实践或实习环节提升综合实践能力	认可	63.16%	64.51%	61.81%
	未定	30.07%	24.82%	35.32%
	不认可	6.77%	10.67%	2.87%
	得分	3.85(0.36)	3.88(0.41)	3.81(0.21)
教学实践或实习环节培养协作意识	认可	54.80%	60.2%	49.40%
	未定	38.05%	31.78%	44.32%
	不认可	7.15%	8.02%	6.28%
	得分	3.71(0.41)	3.78(0.21)	3.64(0.33)
教学实践或实习环节提升就业能力	认可	71.80%	66.70%	76.90%
	未定	20.28%	22.23%	18.32%
	不认可	7.93%	11.07%	4.78%
	得分	3.96(0.21)	3.83(0.31)	4.08(0.28)
教学实践或实习环节提升科研能力	认可	27.88%	32.39%	23.37%
	未定	41.90%	41.32%	42.47%
	不认可	30.23%	26.29%	34.16%
	得分	2.97(0.14)	3.09(0.16)	2.84(0.18)

由以上五方面可以看出,除教学实践或实习环节能提升科研能力之外,目前我国高校有 50% 以上的学生认可教学实践或实习环节的功能得分达了 3.7 分以上,在教学实践或实习环节提升综合实践能力、培养协作意识和提升科研能力方面,"985"高校学生的认可度超过了省属院校学生的认可度,但在与课堂教学内容紧密结合和提升就业能力方面省属院校学生的认可度超过了"985"高校学生的认可度,这表明了这两类学校的教学实践或实习环节各自的侧重点,同时也点出了各自学校以后对教学实践或实习环节长远投入方向。

(六)学生对"本科教学工程"总体方面的评价

学生对"本科教学工程"总体方面的评价可以从学习课程后的收获、评教信息反馈与解决、"本科教学工程"促进教学质量改进等三方面来反映。

从表 6 统计结果可以看出,一是有 49.56% 的学生认可学习课程后有很多收获,其中"985"高校有 39.47% 的学生对其表示认可,省属高校有 59.65% 的学生对其表示认可。依据五分量表,学生对其认可得分为 3.59 分,表明学生对学习课程后有很多收获认可不是很高。二是仅有 16.36% 学生认可学校评教信息反馈与解决非常及时,其中"985"高校有 18.31% 的学生对其表示认可,省属高校有 14.40% 的学生对其表示认可。依据五分量表,学生对其认可得分为 2.38 分,表明教学信息反馈机制不畅通的问题无论是"985"高校还是省属高校都普遍存在。三是仅有 14.40% 的学生认可"本科教学工程"明显促进了教学质量改进,其中"985"高校有 12.50% 的学生对其表示认可,省属高校有 16.30% 的学生对其表示认可。也就是说,"本科教学工程"对原办学水平较低的高校教学质量提高作用要大一些;依据五分量表,学生对其认可得分为 2.82 分,表明无论是"985"高校还是省属高校的"本科教学工程"对提高教学质量无明显作用,学校学风和教风均无根本改观。

表 6 学生对"本科教学质量评价体系"总体方面的评价

实施指标		总体	985 高校	省属高校
学习课程后有很多收获	认可	49.56%	39.47%	59.65%
	未定	40.50%	48.33%	32.66%
	不认可	9.95%	12.20%	7.69%
	得分	3.59(0.45)	3.41(0.25)	3.78(0.47)
评教信息反馈与解决非常及时	认可	16.36%	18.31%	14.40%
	未定	26.26%	24.22%	28.29%
	不认可	57.39%	57.47%	57.31%
	得分	2.38(0.21)	2.41(0.14)	2.36(0.35)
"本科教学工程"明显促进了教学质量改进	认可	14.40%	12.50%	16.30%
	未定	59.35%	63.28%	55.41%
	不认可	26.26%	24.22%	28.29%
	得分	2.82(0.17)	2.82(0.47)	2.82(0.64)

三、结论与建议

从以上分析中不难得出如下结论:第一,"本科教学工程"实施了 7 年,无论是"985"高校还是省属高校,总的来说教师在课程设计、课堂教学环

节的能力都得到了绝大多数学生的高度认可,这表明"本科教学工程"已经取得了一定的成效。第二,"985"高校相对于省属高校,在优秀教材选用,教师授课准备,教师知识储备,教师的教学方法,学生参与课堂积极性,教师答惑解疑,教学实习或实验培养协作意识培养和提升科研能力等方面得到学生的认可度高于省属高校学生对其的认可度;但在专业培养目标明确性,课程目标清晰性,课堂气氛活跃,实习或实验与课堂教学内容紧密结合,实习或实验提升就业能力和学生学习课程后有很多收获等方面得到学生的认可度低于省属高校学生对其的认可度。第三,尽管取得了一些成绩,但也应该看到,"本科教学工程"在实施过程中还存在不少问题:一是无论是"985"高校还是省属高校,学生对其专业培养目标明确性的认可度低,有 50%以上的学生认为专业培养目标不明确;二是学生对其选用国内外优秀教材和教材的时效与创新性的认可度很低,有 59%的学生认为很多教材并不是国内外优秀教材,教材缺乏创新性且内容陈旧;三是学生认为课堂气氛活跃性差,有 60%以上的学生认为教师授课的生动性,课堂的互动性差甚至缺失;四是学生对实习或实验提升科研能力的认可度很差,70%的学生认为教师指导实习或实验缺乏科研所需的创新能力;五是尽管各学校采取多种教学评估的方式,但对于评估中反映的问题并没有得到及时纠正,导致评估在很多学校基本上流于形式。正是因为"本科教学工程"存在上述诸多问题,学生作为"本科教学工程"服务对象和最终受益者,他们对实施 7 年的"本科教学工程"评价并不高,有 83.61%的学生反映"本科教学工程"对提高教学质量无明显作用,学校学风和教风均无根本改观。

基于对我国当前高等教育"本科教学工程"实施现状的考察,本研究认为,要进一步推进"本科教学工程"建设,应着手做好如下几个方面的工作:一是依据社会人才需求变化对不同层次和类型高校的不同学院的专业培养目标进行准确定位;二是规范评审国内外优秀教材程序,严格把好评审关;三是把教学"重投入"的阶段性改为持续性;四是注重学生评教权力和利益得到真正实现,完善"本科教学工程"建设事前、事中和事后的"全过程"跟踪监督评价机制。

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(本文责任编校:周献)

Analysis on the Effect of Universities´ Undergraduate Teaching Quality Project: Based on Evaluation Questionnaires from Six Agri–Forestry Universities

LI Hua，YAO Shun-bo

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[**Abstract**] In order to investigate the implementation effect of the "Undergraduate Teaching Quality "since 2007, the research group conducted a undergraduate questionnaire survey on 6 university in Shaanxi Province. Analysis shows: 50% undergraduates have approved the teachers' improvement on their curriculum design and classroom teaching performance since the implementation, but over 50% undergraduates have not accepted the improvement in the education goal, the updated content of courses and textbooks, and the improvement in the abilities of securing a job or doing scientific research through practice and experiment training. Therefore, we might conclude that the implementation effect of the project has not reached the expectation of the designed goal so far.

[**Key Words**] Agriculture & Forestry Universities; Undergraduate Teaching Quality Project; Implementation Effect

:计量经济学课程的重要性已经得到普遍承认,然而目前计量经济学教学中仍然存在一些问题,导致传统的实践落后于理论问题变成目前的实践落后于理论和理论落后于实践问题并存,影响了教学效果的提高。针对这些问题和原因,本文提出基于"学、拓、化"三位一体架构下的计量经济学教学模式,把理论教学和实践教学有机结合,以促进教学效果的提高。

:计量经济学;"学、拓、化"架构;教学模式

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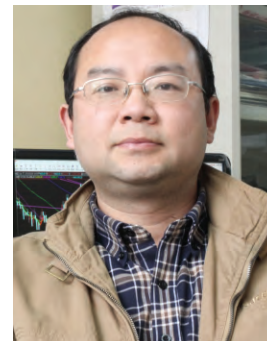
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:高校实验室是教学、科研工作的重要组成部分,是提高学生创新能力、动手能力、实践能力及综合素质的重要基地,是培养学生的科学素质、团队精神和提高他们竞争能力的一个重要保证。为此,利用二元因变量的分析方法,对样本采用 enter 方式研究文科实验室能否对大学生的学习起到良好的作用的影响因素。结果发现,文科实验室环境建设将对提升大学生技能起到较大的作用。其中年龄、年级、对课程实验是否了解并进行预习、对实验室是否有心理上的适应和对实验室专业环境氛围建设有何评价在文科实验室能否对大学生的学习起到良好的作用的影响因素起到了正向作用。

:文科实验室; 大学生技能; 二元 Logistic 模型

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Research on the Construction of Arts Laboratory Environment and Upgrading College Students' Skills Based on Binary Logistic Model

WANG Yu-tao

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Abstract: The university laboratory is an important part of teaching and science research is an important base to improve students' innovative ability practical ability practicing ability and comprehensive quality is an important assurance to cultivate the students' scientific quality team spirit and their competition ability. This paper uses binary logistic model to research the construction of arts laboratory environment and upgrading college students' skills and to find the influence factors. It finds that liberal arts laboratory environment construction will greatly affect on the promotion of college students' skills. The age grade understanding and preview the course of experimental psychological adaptation to the laboratory layout and environment in the liberal arts laboratory could play a positive role play to upgrading college students' skills. The biggest role is whether the psychological adaptation of the laboratory.

Key words: arts laboratory; college students' skills; binary Logistic model

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表 1

$X1$		286	1.00	2.00	1.4560	.40785
$X2$		286	19.00	24.00	21.4286	9.47856
$X3$		286	1.00	4.00	2.78568	1.12078
$X4$		286	0.00	1.00	0.68548	0.210756
$X5$		286	1.00	5.00	3.87647	2.45869
$X6$		286	1.00	5.00	4.10264	2.28197
$X7$		286	0.00	1.00	0.8934	0.34876
$X8$		286	0.00	1.00	0.87642	0.49896

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$$P_j = F\left(\alpha + \sum_{i=1}^{m} \beta_i x_{ji} + u\right) =$$

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$$1 / \left\{ 1 + \exp\ -\ \left(\alpha + \sum_{i=1}^{m} \beta_i x_{ji} + u\right) \right\} \quad (1)$$

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$$\ln \frac{P_j}{1 - P_j} = \alpha + \sum_{i=1}^{m} \beta_i x_{ji} \quad (2)$$

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		1	2	3	4	5	+
		1	0				+

表 3

	B	$\text{Exp}(B)$	Wald	Sig.
$X1$	-0.206	0.574	4.864	0.037
$X2$	0.021	1.248	6.178	0.028
$X3$	0.124	0.166	9.493	0.001
$X4$	0.078	0.874	7.218	0.021
$X5$	0.158	1.385	14.208	0.000
$X6$	0.256	2.274	12.104	0.000
$X7$	0.247	2.198	24.317	0.000
C	-2.158	10.984	8.194	0.001

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$$Y = F(X1\ X2\ X3\ X4\ X5\ X6\ X7) \quad (3)$$

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　　　J. 　　　2010 29(7): 216–
218.

13　　　　　.
　　　J. 　　　2011 30(11): 90-94.

14　　　　　.
　　　J. 　　　2012 31(4): 291-293.

15　　　.
　　　J. 　　2010 29(3): 114-117.

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　　　　2000(2): 133–135.

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2009(5): 140-143.

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J. 　　　（　　　）2008(7): 230–
231.

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J. 　　（　　　）2011(12): 1-2.

13　　. DEA　　　　　J.
2011(9): 72-73.

14　　　.
J. 　　　2011(8): 419-422.

15　　.　　　　J. 　　2009
(13): 155-156.

■人才培养模式

（西北农林科技大学,陕西 杨凌 712100）

:高等农林院校金融人才培养模式应具有自身的特点。通过对目前高等农林院校金融专业人才培养模式的分析表明,高等农林院校金融专业人才培养模式未突出农林高校的特点,人才培养体系缺乏系统性,实践教学环节薄弱。高等农林院校应从这三方面着手改革金融专业人才培养模式。

:高等农林院校;金融专业;人才培养模式

6

[1]。

（三）课程体系的设置

（一）人才培养目标

（二）人才培养质量的基本要求

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（一）人才培养体系未突出农林院校的特点
“   ”   “   ”

51

（一）应突出农林院校的特色

（二）构建系统性的应用型农村金融人才培养体系

（二）应用型农村金融人才培养缺乏系统性

（三）加强实践教学环节建设,提升金融专业学生的能力和素质

（三）实践教学环节薄弱

[1] . ——
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[2] . [J].
2010 (9).
[3] [J]. 2008 (2).
[4] [J]. 2007 (8).
[5] . [J]. 2012 (1).

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图1

18.75%

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[8]

P=1

P=0

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15　　（　）

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52.08%　　46　　47.92%

64　　　　66.67%。

2.

66.91%

33.33%　　　　　33.58%

图2

2

43.75% 、
16.67% 、 14.58% 、 10.42% 、
6.25% 、 4.17% 、 2.08% 、
2.08% 3 。

43.75%、 35.42%、 14.58%、
4.17%、 2.08% 2 。

79.17%

8% 。

	实际签约职位	期望职位
管理	35.42%	16.67%
销售	20.83%	43.75%
技术	16.67%	14.58%
行政	10.42%	6.25%
财务	8.33%	16.67%
人力	4.17%	22.92%
服务	2.08%	10.42%
其他	2.08%	2.08%

3

16.67%

15% 35.42% 。

43.75% 20.83% 10.42%
2.08% 。

5%
43.75%

（ ）

4

（ ）

	实际工作地点	期望工作地点
城乡村镇	4.17%	4.17%
小城市	8.33%	8.33%
中等城市	37.50%	37.50%
其他大城市	22.92%	22.92%
北上广深	27.08%	27.08%

4

20.83%
45.83% 66.66% 。

37.5%

27.08% 22.92%

10.42%

2000～3000

2000 4000

2000～3000 37.5%

3000～4000 33.33%

2000～4000

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7

" " 89.58% "

" 6.25%。

" " 72.92%

" "、" "、" "

" " 89.58%

72.92% 17%。 "

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0

3.

8 72.92%

18.75%

6.25%

000%   833%
≥70 000% 417%
417% 145%
51～70 395%
41～50 5625%
5625%
≤40 166%

000% 1000% 2000% 3000% 4000% 5000% 6000%

图5

5 40

50

8

41～50

56.25% 40 16.67%

51～70 14.58%。

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1.

6 。50% 20.83%、 39.58%

4000

3000～4000 60%

20.83%

50%

416%
0%
4000 50%
2292%
3000-4000 3542%
3333%
2000-3000 1042%
37.50%
2000 0%
625%

000% 1000% 2000% 3000% 4000% 5000% 6000%

图6

4.

9

64.58%、

60.42%、 50%、

41.67% 41.67%

77.08%、 58.33%、

64

7

8

54.17% 、 54.17% 、

37.5% 。

9

40

37.5%、25%

60.42%、64.58%

[9]

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[1] · ， · . [M]. .
， ， : ,2004:34-35.
[2] .
[M]. : ,2002:75- 77,60- 61.
[3] . 2002
[M]. : ,2001:48-53.
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[J]. ,2008(01):17-19.
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: ,2005(03):42-44.
[7] . ——
[J]. ,2009(02):
51-54.
[8] . [J].
,2009(01):24-26.
[9] . [J].
,2009(01):17-19.
[10] . [J].
,2008(12):39-40.

specialty setup of Public Utilities Management. The practice teaching of Public Utilities Management Specialty caters to the diversified needs of the society and students in the format of "Theory-Simulation-Application-Innovation". The overall hierarchy consists of curricula with multiple modules under the support of the practice teaching course group. At the same time, the operation mechanism and collaboration relation should be perfected to accomplish the "separation-centralization-integration" and maintain the stable operation of practice teaching system. Besides the construction of the practive teaching system through the holistic approach with intra- and extra-curricula as well as intra- and extra-mural resources, the comprehensive appraisal should be applied to ensure the practical teaching effect.

Key Words   Practical Teaching; Public Utilities Management; System; Operational Mechanism

（   56   ）

A Discussion about Project Pattern as a New Talent Training Mechanism with the Example of "Students Innovation Experiment Plan"

ZHAO Lu WANG Jun

(Northwest A&F University Innovative Experimental College, Yangling 712100, Sha'anxi, China)

Abstract   As a new mechanism of talent cultivation, Project Pattern aims at breaking through the tradition syllabus of courses plus practive model and introducing the research project mechanism so that undergraduates are involved in the project for the purpose of curriculum study and skills acquisition. The College of Innovation and Experiment of NWAFU explored the role of Project Pattern in the undergraduate program and attempted to initiate the new talent cultivation mechanism through the approach of Project Pattern.

Key Words   Project Patten; "Students Innovation Experiment Plan"; Talent Training

（   66   ）

A Comparative Study of College Students´ Employment Expectations and the Actual Employment Contract: A Survey of 2012 Batch Graduates´ Employment Status of Northwest A&F University

MA Hong-yu, WANG Shao-kun, XIA Xian-li, YANG Zhi-lin

(Northwest A&F University, Yangling712100, China)

Abstract   On the basis of survey data from 2012 batch graduates of Northwest A&F University, the students' employment expectations and the actual employment contract were compared and the negative influences were analyzed. Counter-measures beneficial for government, enterprises, universities and graduates were put forward. This survey had the implications for deepening the graduates employment, upgrading the quality of employment and providing references for the employment units and university graduates.

Key Words   University Students Employment; Actual Situation; Expectation

ERP

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(,   712100)

:在广泛借鉴现有研究成果的基础上,通过设计调查问卷,以西北农林科技大学经济管理学院工商管理专业的学生为调查对象,对 ERP 模拟教学培养能力的效果进行了分析评价。结果表明,ERP 沙盘模拟教学对工商管理专业学生能力的培养效果良好。

:ERP 沙盘模拟教学;工商管理专业;能力培养;效果分析

,ERP(enterprise resource plan)

[1]。 ERP
        1978   ,

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[2]。   ,ERP

ERP

                    2008   － 2010
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ERP   《   》,
                        ERP

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ERP

42

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ERP ， 171 ，165 ，

4—6 ， 96.49%。ERP

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[4] 。 ， ， 1。

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5. ，

ERP ， （ ）

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， | 序号 | 评价指标 | 平均值 | 最大值 | 最小值 | 标准差 |
|---|---|---|---|---|---|
| 1 | 专业知识综合运用能力 | 4.06 | 5 | 2 | 1.10 |
| 2 | 自主学习兴趣 | 3.09 | 5 | 1 | 1.40 |
| 3 | 沟通能力 | 3.35 | 5 | 1 | 1.39 |
| 4 | 团队协作精神 | 3.83 | 5 | 2 | 1.06 |
| 5 | 分析与解决问题能力 | 3.55 | 5 | 1 | 1.35 |
| 6 | 抗挫折能力 | 3.21 | 5 | 1 | 1.26 |
| 7 | 诚实守信品格 | 2.42 | 4 | 1 | 1.06 |
| 8 | 创新与共赢意识 | 3.23 | 5 | 1 | 1.30 |

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8. ERP ，

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[5] ，ERP

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3 ， 38.79%，3

、 61.21%， 1 3.09，

2010 ， ERP

ERP 。

， 3. 。89 4

， ERP 5 ， 53.94%， 1 ，

43

3. 35, ERP ,113 3 ,
31. 52％ 68. 48％, 1 ,
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4. 。 1 , 3. 21, ERP
3. 83, ERP 。
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3 , 85. 45％, 2. 42 , ERP
34. 55％ 57 5 ; ERP ; 2 ,
。 23. 03％ 38 4 ,
5. 。 41 5 , 76. 97％
3 ,41 3 ,83 3 , ERP
3 , 。
24. 85％、24. 85％ 50. 30％, 1 , 8.
3. 55, ERP 30. 30％ 50 3 ,
; ERP 44. 85％ 74 4 , 1
。 3. 23 , ERP
6. 。 52 3 。

<p style="text-align:center">2 ERP</p>

指标		1	2	3	4	5	合计
专业知识综合运用能力的提高	数量（名）	0	20	21	41	71	165
	比例（％）	0	12. 12	12. 73	32. 12	43. 03	100. 00
	累积比例（％）	0	12. 12	24. 85	56. 97	100. 00	/
自主学习兴趣的提升	数量（名）	28	36	30	35	36	165
	比例（％）	16. 97	21. 82	18. 18	21. 21	21. 82	100. 00
	累积比例（％）	16. 97	38. 79	56. 97	78. 18	100. 00	/
沟通能力的培养	数量（名）	23	29	24	45	44	165
	比例（％）	13. 94	17. 58	14. 55	27. 27	26. 67	100. 00
	累积比例（％）	13. 94	31. 52	46. 06	73. 33	100. 00	/
团队协作精神的培养	数量（名）	0	24	37	47	57	165
	比例（％）	0	14. 55	22. 42	28. 48	34. 55	100. 00
	累积比例（％）	0	14. 55	36. 97	65. 45	100. 00	/
分析与解决问题能力的培养	数量（名）	14	27	41	36	47	165
	比例（％）	8. 48	16. 36	24. 85	21. 82	28. 48	100. 00
	累积比例（％）	8. 48	24. 85	49. 70	71. 52	100. 00	/
抗挫折能力的培养	数量（名）	17	35	43	39	31	165
	比例（％）	10. 30	21. 21	26. 06	23. 64	18. 79	100. 00
	累积比例（％）	10. 30	31. 52	57. 58	81. 21	100. 00	/
诚实守信品格的培养	数量（名）	35	64	28	38	0	165
	比例（％）	21. 21	28. 79	16. 97	23. 03	0	100. 00
	累积比例（％）	21. 21	60. 00	76. 97	100. 00	100. 00	/
创新与共赢意识的培养	数量（名）	20	30	41	40	34	165
	比例（％）	12. 12	18. 18	24. 85	24. 24	20. 61	100. 00
	累积比例（％）	12. 12	30. 30	55. 15	79. 39	100. 00	/

44

3

综合得分	[10,15)	[15,20)	[20,25)	[25,30)	[30,40)	合计
数量(名)	8	29	37	52	39	165
比例(%)	4.85	17.58	22.42	31.52	23.64	100.00
累积比例(%)	4.85	22.42	44.85	76.36	100.00	/

3　　　，　　　　　22.42%　37
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Analysis on Ability－building Effectiveness of Management Specialty Students Through ERP Sandplay Mock Teaching

XUE Cai－xia,YAO Shun－bo

(College of Economics and Management,Northwest Sci－Tech University of Agriculture and Forestry,Yangling 712100,China)

Abstract:On the basis of draw lessons from the existing research,through the design of the questionnaire,students of business administration majors for the survey in the Northwest A ＆ F University of the Economics and Management college,the ERP sandplay mock teaching effects were analyzed and evaluated. The results showed that ERP sandplay mock teaching got good effect for business administration students' ability－building.

Key Words:ERP sandplay mock teaching;management specialty;ability－building;effectiveness analysis

Survey Research on the Situation of College Students' Study Engagement
——Comparative Studies on X University and Tsinghua University

ZHU Hong－can

(Public Administration School of Xiangtan University,Xiangtan 411105,China)

Abstract:On the base of NSSE－China survey,X University is compared with Tsinghua University on main educational practices and students' self－reported gains. The problems of main educational practices in X University is identified and analyzed,and solutions are put forward.

Key Words:college students;study engagement;survey

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	54	42	
	35	27	
`	60	47	128
	38	30	
	30	23	
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	40	31	128
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	51	40	128
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	45	35	128
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	61	48	
	60	47	
	11	9	128
	79	61	
	38	30	
	8	6	128
	56	44	
	64	50	

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（ 9）：

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	17	13	128
	92	72	
	19	15	
	10	8	128
	81	63	
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186.
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　　［J].　　　　，2009(6)：76-77.
［4］　　，　．　　　：　　　［J].
　　：　　　　，2007(6)：86-91.
［5］　　，　，　．　　　　　　　［J].
　　，2007(6)：130-133.
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　　［J].　　　　，2012(3)：230-234.
［7］　　，　，　，　．
　　［J].　　　，2012(7)：40-42.
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　　——　　"　　"　［J].
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中国农业教育

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| 新型经营主体特性与农业经理人职业定位 | | 农业职业经理人胜任素质 |

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┌─────────────────────────────────────┐        ┌──────────────────────┐
│ 农业投入                              │ ┌─一二三产业融合─┐ │ 产业融合思维与能力    │
│ "成本地板"    经济    产业链延伸      │ │              │ │                      │
│              组织                     │ │  文化创意    │ │ 文化创意思维与能力    │
│ 农产品"价    特性    农业功能拓展     │ │              │ │                      │
│ 格天花板"                             │ │  互联网+     │ │ 互联网+思维与能力     │
│              规模化                   │ │  农业       │ │                      │
│ 生产经营特性  集约化                  │ │              │ │ 农业及其政策法规      │
│              市场化                   │ │ 农业生产的   │ │ 知识                 │
│ 农业特性                              │ │ 基础性      │ │                      │
│                                       │ └──────────────┘ │ 基本职业素质和        │
│ 职业定位      中高层管理者            │                   │ 专业技能             │
└─────────────────────────────────────┘                   └──────────────────────┘
                                          六次产业理念
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基准性胜任素质

知识技能 ← 农业及其政策法规知识 管理者的基本职业素养 和专业技能

区辨类 角色定位价值观 ← 产业融合思维、文化创意思维、互联网+思维等

水平面

鉴别性胜任素质

转化类 特质动机 ← 实现产业融合、文化创意、互联网+的能力

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［J］．　　　　2015（13）：49-51.

［2］ ．　　　　　　　［J］．　　2015
（6）：36-37.

［3］ ．　　　：　、
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2010（10）：16-26.

［4］ ．
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2016（4）：3-28.

［5］ ．
［J］．　　　　　　2016（6）：23-32.

［6］ ．
　　　　［J］．　　2015（10）：73-77.

［7］ ．
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［J］．　　　2016（1）：57-63.

［8］ ．　　2016（2）：54-54.

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9 ．"   " J ． 2016
(6) : 6-7.
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—— J ．   (
) 2015(1) : 194-197.
11 ．
—— J ． 2012(11) : 15-16.
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13 ． J ．
2016(1) : 1-5.
14 ． "   "
J ． 2015(3) : 5
-10.
15 ． ——
M ． : 2005: 89.
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Working in America: *Blueprint for the New Labor Market* M ．
Cambridge: The MIT Press 2001: 28.
17 ．
J ． 2013(13) : 33-33.
18 ．
J ． 2014(19) : 43-44.

19 ． J ．
2015(5) : 107-108.
20 McClell D C. Testing for competencies rather than
intelligence J ． *American Psychologist* 1973(1) : 1-14.
21 ．
J ． 2013(4) : 4-11.
22 ．
J ． 2016(5) : 66
-70.
23 ． :
、 J ． 2015(3) : 108-112.
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J ． 2017(6) : 28-30.
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J ． 2004(6) : 29-33.
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" J ． 2012(4) : 14-28.
27 ． J ． 2015
(6) : 79-79.
28 ．
J ． 2006(1) : 162-168.
29 ．
J ． 2014(4) : 26-35.
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The Practice and thoughtsof using WeChat Official Platform in Graduate Enrollment: Taking Nanjing Agricultural University as an Example

GAO Chan   ZHOU Zi   ZHAO Chen

（Nanjing Agricultural University   Nanjing210095   China）

Abstract   With the rapid development and popularization of the Internet and smart mobile devices   WeChat official platform has gradually replaced other media as an effective official platform for university publicity. This paper starts from the development situation of WeChat public platform of "NJAUYZB" and comparison with other public accounts of other universities   and summarizes the pressing problems in practice   in order to explore its future development and seek effective ways of information publicity.

Improving the Working Style of University Administration Through "Secretary Project"

ZHU Zhu   ZHUANG Sen   HU Zhengping

（Nanjing Agricultural University   Nanjing 210095   China）

Abstract   The working style construction of administration of universities is related to the efficiency of university leadership and management and the sustainable development of universities. To carry out the "secretary project" in the grass-roots Party construction is an important way to improve the working style of university administration. This article   combined with the practice of working style construction through "secretary projects" in the grass-rootsadministration under the Party Committee of Nanjing Agricultural University   analyzed and summarized the effect and achievements of the Party construction at the grass-roots level through "secretary project"   and discussed how to do a better job in terms of the project.

Study on the Training of Agricultural Professional Managers Based on the Concept of Six Industries Concept and Competence Iceberg Model

XUE Caixia   LIU Chao   YAO Shunbo

（Northwest A&F University   Yangling 712100   China）

Abstract   Promoting the industrial integration is an important way to broaden the channels of increasing farmers' income and building a modern agricultural industry system. Agricultural professional managers are the "bellwethers" that lead farmers to participate in industrial integration. The present training of the agricultural professional managers faces difficulties such as lacking systemic and theoretical guidance so that the agricultural professional managers are not able to achieve their goals. The industrial integration is the core of six industrial concepts. Based on the six industries concept and competence iceberg model and analyzing the competency of agricultural professional managers   this paper established the competence iceberg model for the agricultural professional managers on the basis of six industrial concepts. From the competence iceberg model   the paper evaluated the effectiveness of the current professional manager training and put forward the path systemically for the training of agricultural professional managers.

On the Cultivation of Modern Young Farmers Based on PDCA Model: Exemplified by Jiangsu Animal Husbandry Vocational College

HU Yongsheng   FEI Hanhua   QIAN XiaoLi

（Jiangsu Animal Husbandry Vocational College   Taizhou 225300   China）

Abstract   Focusing on the problem of speeding up the construction of modern professional farmers   this paper conducted a questionnaire survey on the basic situation of young farmers and their training needs by sampling statistics   analyzed the needs for the management of training   training cost and training content. Based on the

- 296 -

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:大学生领导力是大学生综合素质的体现,有助于大学生的人格发展、非专业素质的培养和健康心理的养成。本文通过对大学生领导力的培养途径与方法进行梳理总结,在借鉴美国高校大学生领导力课程体系建设的基础上,创新提出我国高校大学生领导力培养和提高的基本建设思路。

大学生领导力;培养;途径;发展思路

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[1]杨瑞东,倪世光.美国高校大学生领导力教育的调研与借鉴[J].思想教育研究,2015,(1):98-102.
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[1] ， . [J]. ，2011，（9）：46–47.

[2] ， . ： [J]. ，2013，（12）：118–119.

[3] . [J]. ： ，2013，（4）：54–59.

[4] ， . [J]. ，2004，（10）：36–43.

[5] ， . 、 ： [J]. ，2014，（3）：48–60.

[6] . [J]. ，2015，（2）：64–66.

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G71　　　　　　　A　　　　　2096–000X 2015 05–0076–03

Abstract: The accounting teaching in simulation practice is very important to improve the teaching quality of ac-counting , to promote the students professional employment of accounting. As a main investigation object of account-ing professional undergraduate in some universities of agriculture and forestry ,this paper discusses the satisfaction of the accounting simulation practice teaching, analyzes the existing problems, and puts forward the countermeasures to perfect the accounting simulation practice teaching.

Keywords: accounting simulation; the practice teaching; satisfaction

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2008 2 .

[8] 　　.　　　　　　　　　　　[J].
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STC89C52

数码管显示 ← STC89C52 单片机 → 继电器 → 水泵

超声波模块 ↔ ← 键盘

超声波探头

复位 → 声光报警

水位

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电源

图 2

[1] 　　.　　　　　　C 　　　[M].
　　2009.

[2] 　　.　　　　　　　　　　[M].
　　2009.

[3] 　　.　　　　　　　　　　[J].
　　2008 27 4 160–162.

[4] 　　.　　AT89C51
　　[J].　　　2013 2 21–24.

[5] 　　.　　　　　C
　　[J].　　　　2010 25 6 28–29.

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G71   A   2096−000X 2015 06−0080−02

Abstract: With the increasing application of the ERP software in company, the internship of ERP gradually be−comes a key and difficult point in advanced education, especially in university education. This essay makes a project of the satisfaction about ERP internship, which is based on the time ,the environment, the textbook, the instruction, the content and effect about internship.The research shows that the satisfaction of ERP internship is not very well. Specifically, the effect of internship has the most significant implication of the satisfaction. Then followed by the en−vironment, the instruction, the content and the time. Comparing to the others factors, the textbook make the less in−fluence on satisfaction. In addition to this, the essay provides the relevant suggestion to complete the ERP software´s internship.

Keywords: ERP software internship; practical teaching; satisfaction; Li kete´s Five Scaling Method

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	N	Maximum	Minimum	Mean	Std. Deviation	Variance
实习时间	156	5	1	3.7154	.8184	.6729
实习环境	156	5	2	3.7692	.7791	.6152
实习教材	156	5	1	3.6126	.8313	.6918
实习指导	156	5	1	3.7308	.7360	.5474
实习内容	156	5	1	3.7212	.7015	.4931
实习效果	156	5	1	3.7874	.7073	.5040

表2

	N	Maximum	Minimum	Mean	Std. Deviation	Variance
总体满意度	156	5	2	3.8013	.686	.470

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2012 3 :100-103.

[3]　　　　　　.　　　.
2006 10 :72-73.

[4]　　　.　　　　　[J].
2003 3 .

[5]　.　ERP　　　　[J].
2008 16 .

Hans 汉斯

Research on the Design of Micro Teaching Based on SWOT Analysis in Shaanxi Province

Hongsong Liang, Shuangshuang Liu*, Huifeng Xu

College of Economics and Management, Northwest A & F University, Yangling Shaanxi
Email: lianghongsong@126.com, *1462817798@qq.com

Abstract

As a kind of micro online teaching mode, the micro teaching is becoming more and more popular in recent years. As a big province, Shaanxi still has problems in education, such as, the distribution of educational resources is not balanced, the utilization rate is not high and so on. This paper aims to promote the reform of higher education in Shaanxi province under the new situation of Micro Teaching. This paper discusses the origin and development trend of the micro course, and analyzes the characteristics of the online teaching mode by using the SWOT analysis method. According to the characteristics of Shaanxi Province Education which is located in the remote areas and who has many minority cultures, rich and unique natural resources. This paper puts forward the development plan and the corresponding evaluation system and the prospect of the development of micro teaching in university is discussed.

Keywords

Micro Course, SWOT Analysis, University Alliance, Evaluation System, Shaanxi Province

基于SWOT分析的陕西高校微课模式设计研究

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西北农林科技大学经济管理学院，陕西 杨凌

*通讯作者。

摘 要

微课作为一种表现微型课堂教学形式的在线式网络教学模式，近年来越演越热。陕西省作为一个教育大省在教育方面仍然存在教育资源分布不均衡，利用率不高等问题。本文旨在促进陕西省高等教育在微课教学新形势下的又一大变革。文章论述了微课的起源、国内外发展趋势，运用SWOT分析法分析了微课这种网络教学形式的特点。针对陕西省地理位置偏远、少数民族文化众多、自然资源丰富和独特等教育特点，提出了针对陕西省高等教育的发展方案和相应的评价体系，并展望了微课在高校联盟中的发展前景。

关键词

微课，SWOT分析，高校联盟，评价体系，陕西省

1. 研究背景

自文革以来，陕西省的教育事业一直处于一种蓬勃发展的状态。至今，陕西省已发展成为全国高校最多的一个省份，教育水平已初具规模。陕西省拥有多所专业门类比较齐全、多种人才培养规格相配套的普通全日制高等学校、中等专业技术学校和相当数量的成人高等院校。省内有以理工为主的西北工业大学、长安大学、西安电子科技大学；以师范为主的陕西师范大学；以农林为特色的西北农林科技大学；以语言为主的西安外国语大学还有综合性质的西北大学和西安交通大学等。

随着网络技术的发展，国外兴起了以一种"微课""慕课"等为主的网络在线微视频教学形式。最近，随着微课的引进，国内也逐渐掀起了一股教育热的浪潮，这对陕西省无疑是一个巨大的教育改革契机。陕西高校也相继引入微课教学方式，提倡高校教师参加全国性微课教师评比大赛。新一轮网上教学改革正如火如荼地展开，而微课这种时间短，易接触的教育形式在网络时代的今天，无疑会发展成为一种新型的教学模式。

然而，微课在陕西省高校的发展仍面临着一些问题：(1) 宣传力度不足，虽然高校大力提倡，但很多教师和大部分学生根本不了解微课是什么；(2) 局限于形式，部分老师不懂得正确的运用微课教学；(3) 现代教学手段和教学资源利用率不足；(4) 教师能力有限，部分资深教师对录屏软件等熟悉程度不足，操作能力有限。针对以上问题，为使微课这种教学形式在陕西省得以充分发展，从而促进陕西省高等教育事业的进步，提高学生学习的主动性和自主性，使网络变为我们学习的一种有力工具显得尤为重要。

本文运用 SWOT 分析法分析陕西省教育特点以及微课的特点，参考微课设计原则，提出了微课在陕西省高校的微课发展模式。

2. 文献综述

虽然大量公开免费线上教学课程是 2000 年之后才发展出来的概念，但其理论基础深植于资讯时代之前，最远可追溯至 20 世纪 60 年代。早在 1961 年 4 月 22 日巴克敏斯特·富勒就曾针对教育科技的工业化规模发表了一个演讲。这也是科技化教学首度被提出的一个演讲。

在国外，微课程(Micro-lecture)的雏形最早见于美国北爱荷华大学 LeRoy A. McGrew 教授所提出的 60

秒课程(60-SecondCourse)，它将概念讲解和举例浓缩到这么短的时间内，用于有机化学知识的普及[1]。以及英国纳皮尔大学 T. P. Kee 提出的一分钟演讲(The One Minute Lecture，简称 OML) [2]。现今热议的微课程概念是 2008 年由美国新墨西哥州圣胡安学院的高级教学设计师、学院在线服务经理 David Penrose 提出的[3]。他提出建设微课程的五步骤：罗列教学核心概念；写 15~30 秒的介绍和总结，为核心概念提供上下文背景；录制长为 1~3 分钟的视频；设计引导学生阅读或探索课程知识的课后任务；将教学视频与课程任务上传到课程管理系统[4]。

国内微课发展的首发人佛山市教育局胡铁生先生曾这样定义微课[5]：微课又名微课程，它是以微型教学视频为主要载体，针对某个学科知识点(如重点、难点、疑点、考点等)或教学环节(如学习活动、主题、实验、任务等)而设计开发的一种情景化、支持多种学习方式的新型在线网络视频课程。2012 年是国内微课建设和发展的"元年"[6]。2010 年、2011 年微课只在国内少数几个地区、部分学校有探索性建设和应用。而到了 2012 年，微课的"星星之火"便展开了"燎原之势"，"翻转课堂"、"可汗书院"、"混合学习"等教育创新项目迅速走红而成为教育界的热点话题。随着国内外微课实践的不断丰富和相关研究的逐步深化，人们对微的认识也越来越深刻、全面，其概念内涵也在不断发展、丰富。2014 年 5 月 8 日，教育部"爱课程"中国大学 MOOC 平台正式开通，全国高校可通过此平台进行 MOOC 课程建设和应用。

国内现有的关于微课的研究调查主要集中在以下几个方面。

(1) 以一个具体问题或者案例分析微课的设计与制作方法和技巧。比如，东北师范大学的张琛和刘正 (2014) 就以一个具体的火车过桥问题提出微课开发的第一步是合理选题，设计环节则是微课制作的具体规划的想法，具体讲述了教学设计、结构设计和交互界面设计等问题[7]。余胜泉，和陈敏(2013)、王同聚(2014)、孟祥增等(2014)都对微课的设计制作进行了研究[8]-[10]。

(2) 微课在某一具体课程方面的应用。刘慧霞等(2012)针对高职高专生的生理学教学提出了针对性的微课应用方案[11]。张在柱，韩英(2014)对微课在高中教学中的设计与制作进行了详细阐述[12]、胡林峰 (2014) 等结合单克隆抗体技术的医学课程对微课特点进行了分析，并提出了一种微课教学模式[13]，廖惠敏，黄再萍(2014)以社会心理学为例对微课的教学资源方面的建设进行了实践与探索的分析、常彦君 (2014) 对体育精品课程的微课应用进行了分析[14] [15]。

(3) 对微课的概念辨析、发展现状分析或者前景预测。中国微课引领者之一胡铁生(2011) [16]就对我国区域发展的瓶颈做了剖析，总结了微课开发步骤及途径，并对微课在国内的发展做了深度展望。韩庆年，柏宏权(2014) [17]对在线教育下的微课的概念、类型和发展都作出了自己的分析与判断，赵国辉(2014) [18]和林鹏(2014) [19]从不同的方面对微课的概念进行了辨析，胡铁生，周晓清(2014) [20]对微课的发展现状进行了分析，并提出了相应的发展对策，刘红霞等(2014)对微课的教学行为的设计与实践进行了反思 [21]。

国外学者关于 micro-class 或 micro-lecture 的说法较少，但由微课程组成的 MOOCs 研究众多。仅 EI 中关于 MOOC 的权威论文就有 313 篇，其中大量是关于微课在现在时代下流行的必然性分析。De Kereki, Ine and Friss, Paulos, Victor (2015)就乌拉圭地区作为实验先驱经验提倡青少年紧抓 MOOC 学习方式[22]。Nicholls, Gillian M and Restauri, Sherri L (2015)对工程教育方面的在线学习模式有效性进行了评估[23]。Deng, Hui, Shao, Yinjuan, Tang, Yinshan and Qin, Zenong (2014)基于弧模式的比较研究对微视频如何激发学习者学习动机进行了分析[24]。Shafaat, Ali, Marbouti, Farshid and Rodgers, Kelsey (2015)提出了一种新型的MOOC学习模块，并从学生和教师的视角对其优缺点进行了分析[25]。Sun, Ji-Zhou and Liao, Sheng-Feng (2015)分析了 MOOC 的特征和图书馆信息化建设的特点，并在 MOOC 基础上提出图书馆信息资源建设的知识发现模型[26]。

虽然微课概念的提出在国内仅有不到四年的时间，但是国内关于微课的研究调查方面的文献数量并不少，主要集中在微课的设计、制作方法、技巧，在某一方面的应用和概念等优缺点分析上。而国外的关于微课的说法较少，主要是以微课为主的 MOOC 的研究十分精细，很多学术论文专业性极高，在计算机或者生物科学等某一特别的领域对 MOOC 的运用进行了具体分析，也提出了很多专业的网络平台学习模型。尽管微课目前的发展取得了一定成就，但是很少有学者从管理学视角对微课进行系统分析，把微课和区域性发展相结合的研究也比较少。基于此，本文运用管理学分析方法对陕西省高校联盟进行研究，提出了微课在陕西省高校联盟发展战略中的重要作用。

3. 陕西高校微课发展现状及原则

SWOT 是优势(Strength)、劣势(Weakness)、机会(Opportunity)和威胁(Threat) 4 个词英文单词首个字母的串联[27]。为更进一步了解微课在陕西省高校联盟中的运用及发展趋势，本文结合微课的特点，就陕西省高等教育特点分析微课在陕西省发展的必要性。是 SWOT 分析后给出的 SmartArt 直观图。

图 1 运用 SWOT 分析法从微课的特点分析了微课自身所带有的时间短、容量小、内容精、情景化和半结构化的优势。短小精悍既是微课的优点，也是其短板[28]。短小精悍的特点也同时决定了它具有孤立、零碎、信息割裂等致命缺点。而它的网络应用性也决定了其对教师要求高的缺点。微课不光是一个视频片段，包括了教学课件、教案等一系列教学资源。另外，微课类型繁多，微课软件层出不穷。老师们必须熟悉微课种类，认真挑选适合自己的教学方式，花费大量时间学习微课软件，而学生只需要接受老师努力而来的成果即可。所以，微课的教学模式方便的只是学生，对教师的要求越来越高，教师课前的准备工作增多，给教师带来很大的负担[29]。因而微课所方便的是学生而并非老师，从而也使得学生的主动性学习能力减少，变成被动的接受性学习。

陕西省高校众多，教育水平初具规模，生源广阔。然而也正是这广阔的生源决定了教育水平的差异。陕西地处西北，很大一部分学生来自少数民族众多的西北五省，当然也有来自中国东部、东北部、中部、西南和东南的学生。这种参差不齐的状况使得统一性教学变得困难起来，造成部分学生精力过剩，而另一部分学生跟不上课的状态。于是此时，引进微课就显得尤为重要了。这种微课自身优缺点的相互联系性和陕西省自身的教育环境决定了微课在陕西省发展的复杂性。

针对以上 SWOT 分析结果，本文在此给出微课设计几个的原则，微型化原则、开放性原则、时效性原则，并且结合 SWOT 分析的四种战略来设计陕西省微课的发展模式。
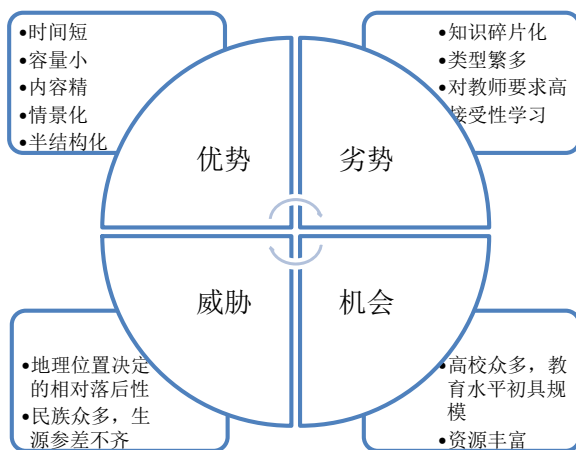
Figure 1. SWOT analysis chart of micro teaching in Shaanxi
图 1. 陕西省微课 SWOT 分析图

如图 2 所示，SWOT 分析后的战略组合有四种，分别为增长型战略、扭转型战略、防御型战略和多种经营战略。根据对陕西省微课的发展情况分析，应该把发挥微课自身优势和陕西省教育资源丰富的机会作为重点，利用杠杆效应，用微课资源的内部优势撬动陕西省现有的教育机会；同时，也必须克服微课的缺点，并把陕西省给微课发展带来的威胁转化为机会。因而，我们需要采取以增长型战略为主，其他三种战略为辅的多战略方式在陕西省发展微课。

4. 陕西高校微课发展的具体方案

本文对微课特点和陕西高校教育特殊性的 SWOT 分析后，相应地针对每一项作出具有针对性的方案，如图 3 所示。对于已有的微课优势和陕西省现有机会，应该做到发扬，即我们要运用微课到实践当中去。在劣势和威胁方面，其本身所带有的劣势可以尽量减小甚至转化为优势，面临的威胁尽量避免，这就需要针对每一项提出解决方法。知识碎片化，指的是微课知识的片段化、零碎，那么如果进行知识整合，将其形成一个系列，将知识系统化就会相应地解决这个问题。还有类型繁多，缺少统一的评判标准等，那就对其进行分类整合，给出评判标准。

4.1. 建立陕西省微课高校联盟

结合高校联盟资源共享的想法，本文提出将微课运用到陕西省高校联盟之中，进而达到更好地运用教学资源、资源共享和降低教育准入门槛的目标。陕西省微课高校联盟的发展战略便应运而生。

目前，高校联盟早已存在，如由北京大学、清华大学、中国科学技术大学、浙江大学、南京大学、复旦大学、上海交通大学、西安交通大学、哈尔滨工业大学组成的九校联盟，此外还有国内九所具有理工科特色的综合性大学组成的卓越大学联盟，国外的也有常春藤联盟、世界大学联盟等，而中外联合的有中欧精英大学联盟和中俄工科大学联盟。这些大学的高校联盟建设之中所共同遵守的原则无疑是"优势互补，资源共享"。而这种高校联盟形式也必将在将来的高校教育之中越发繁盛，越走越远。如果说
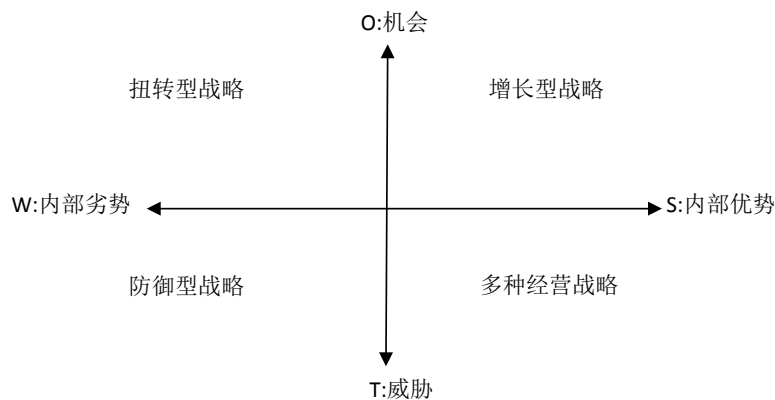
Figure 2. SWOT analysis strategic map
图 2. SWOT 分析战略图
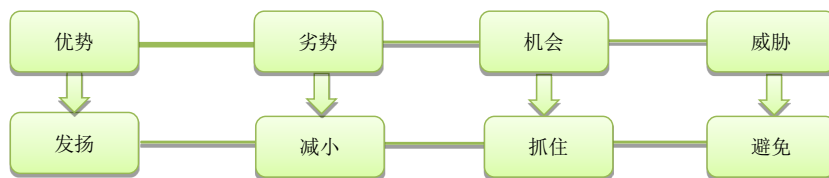
Figure 3. Targeted resolution map of micro teaching in Shaanxi
图 3. 陕西微课的针对性解决方式图

九校联盟是国内优质资源共享的一枝独秀的话，那么微课高校联盟引领的将是一个百花齐放的时代。而陕西省微课高校联盟也将会解决陕西省高校众多，地区相对偏远的问题，建成一个更加卓越先进的大学省份，而不再是单单地在量上取胜。

陕西省微课高校联盟的提出，不是高校的简单加成，而是营造一加一大于二的效果。充分发挥陕西省高校众多的优势，致力于达到优势互补，资源共享的目标。陕西省内大学之间的联合可以充分发挥校内特色、优势专业，并且同时可以让学生学习校外优势资源。不仅优势互补，而且可以强强联合。当然，这些联合的建立是基于大型网络联合的存在的。

(1) 首先，建立一个大型网络平台。各个高校分别选入自己学校的精品课程放入网站之内，学生们则可以根据专业或者兴趣进行注册选课。然后就是在相似学科相同专业间联合开展教材建设，教学与教改研究；联合建立和发布以精品课程为骨干的学分互认课程目录。这样可以让学生上网络课的同时获得其他学校的学分，而学校之间对于此学分是认定的，避免了学生重复选课、浪费时间、浪费精力的弊端。而且也会在教师之间形成一定的竞争机制，让教师更富有动力的进行教课，发挥潜力。

(2) 针对网络课程考试作弊严重等情况，可以充分发挥地域性优势，由于都在一个省份，而且大部分高校在西安，可根据课程特点和在校学生选课人数选择是到选课学校考试、在本校进行授权设点考试还是直接在网上考试。当然，网上考试的监督机制也需要加强。

(3) 充分发挥地域性和网络性的双重机制，形成线上线下双管齐下的学术氛围。在进行网上联络，相互学习的同时，也可以在有时间的情况下进行面对面的交流，可以在假期或者暑假的时候开展统一的暑期训练等活动。

4.2. 陕西省微课高校联盟发展建议

如果不进行大刀阔斧的教学改革，建立大型陕西省微课高校联盟，也可以选择在各高校内部正确地运用微课、使用微课，使得微课发挥其最大的效用。在此提出以下几点建议：

(1) 教师精选内容

教师一定要准确选择合适有用的知识点进行讲解，切忌为了做微课而做微课。这样的话，不仅不会发挥微课平台原有的效用，反而会适得其反，导致资源浪费。教师设计微课的时候要根据课程特点选择难度适中的内容，配以合理的眼神交流、恰当的讲解方式、必要的动作手势，那么一定会收到意想不到的效果。

(2) 校方要为教师提供制作环境平台

校内领导班子和相关部门要做好支持工作，最好给老师们提供一个交流微课制作平台，提供相应的设备，必要时最好找些专业人士对教师们进行微课制作的培训和形成一定的奖励机制。如果校方只是下达文件，却没有任何的实际行动，会使教师们缺乏努力工作的平台和动力，进而也不会达到预期的效果。目前，陕西省部分高校已经在此方面引起了重视。

(3) 教育部大力扶持

陕西省微课高校联盟的建立还需要教育部的大力支持，一个省内高校的大规模教育运动是不能脱离教育部的资金和政策支持的。教育部可以主办类似微课比赛来推进微课教学方式的发展，而陕西省微课高校联盟的建立及发展对陕西高等教育发展的推动作用无疑是显而易见的。

5. 陕西高校微课发展的评价体系

5.1. 评价体系构建

如图 4 所示，针对微课实施每个环节都设定一定的评价机制。(1) 前期选材评价：微课内容适宜精
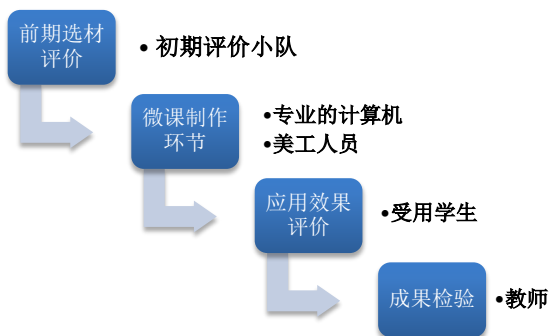
Figure 4. Evaluation system map by micro teaching working process
图 4. 微课制作过程评价体系图

讲重难点。由同一教学小组的教师组成初期评价小队对选材进行评价和提出建议。(2) 微课制作环节：微课技术评价，请专业的计算机和美工人员针对微课质量作出评价。但考虑到教师并不是专业人员，这个要求不应过高。(3) 应用效果评价：由受用学生作为评价人员对此进行评价。(4) 成果检验：教师对未采用微课之前和之后学生的学习成果进行综合性检验，给出评价。

5.2. 教学意义评价

(1) 教师角度

微课形式的出现，颠覆了以往的个别辅导方式，超越了时间和空间，无疑在一定程度上解放了教师。然而，这种形式对今天所有的教师而言，都会是一种全新的挑战，学生的学习可以不再仅仅以教师为主，他还可以在学习网站上找到自己所需要的老师。一些以讲授型为主的教师，也许更易陷入尴尬的境地，学生会觉得这种类型的教师可有可无。微课带给我们一种新鲜的感受和更加生动活泼的教学教研形式，它无疑是现在情境下教学和教研的一种先进手段。微课既可为教师相互学习提供借鉴，又可为教师诊断改进提供依据。同时，微课的出现还能提升教师的信息处理能力和水平。因此，微课的出现为促进教师专业成长提供了新途径。

(2) 学生角度

第一，微课最大的价值在于提高学生的学习效率。一节课的精华总是围绕某个知识点或者某个教学点展开，精彩的、高潮的环节都是短暂的、瞬间的。科学研究表明，学生视觉驻留时间普遍只有 20 分钟左右，若时间过长，注意力得不到缓解，很难达到较理想的学习效果。根据学校实际需求，把教学重点、难点、考点、疑点等精彩片段，录制为时间不足 20 分钟的简短视频。这样使得学生可以随时随地学习，并且注意力高度集中，从而大大提高了学习效率。其次，微课的最大价值还体现在有助于学生自主学习和有选择性学习。随着社会节奏的加快，尤其对大学生来说，要参加一些社团、协会还要参加公益活动和专业实地考察，时间变得越发宝贵。微课的出现可以让学生的学习活动不在局限于教室。可以根据自己的需要，有选择性地打开相关网站或视频，不需要像传统的整堂课一样。即便学生由于某种原因耽误了上课，也不必担心，因为可以通过点播微课加以弥补。

6. 前景展望

近年来，微课的出现在国内掀起了一股教育热的浪潮，各种形式的中小学、大学；省级、国家级微课视频比赛也相继出现，更是推动了微课的发展。2015 年作为国内微课发展的第四年，整个西北地区对微课的发展还远远不够。而陕西省生源充足，教育资源丰富，教育潜力巨大，针对陕西省的教育独特性，结合高校联盟形式的发展，笔者认为，将微课这种教育形式运用到陕西省高校联盟中对陕西省高等教育

的发展前景是无可估量的。而且这种区域性微课教学联盟形式不仅仅对陕西省适用，对其他文化教育水平相似的地区也是如此。

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互联网经济背景下的产业经济学教学改革与实践探索

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摘要： 产业经济学是 19 世纪末期应用经济学领域的重要分支，是现代经济学中用来分析现实经济问题的新兴的应用经济理论。要体现它的应用性特征，就需要把握好经济运行所处的时代特征和市场环境，在大的背景下学习和研究产业的具体问题。互联网与传统产业跨界融合，不仅在很大程度上改造了传统产业，对市场结构和产业的空间分布都产生了前所未有的影响，因此，在互联网经济背景下探讨产业经济学的教学和改革实属必要，是对产业经济学应用性的强化。

关键词： 互联网经济；产业经济学；应用经济学；教学改革

一、产业经济学课程介绍

产业经济学是相对独立的应用经济学科，介于微观经济学和宏观经济学之间的偏微观的经济学，以产业为研究对象，研究和探索产业内企业间的竞争、合作关系及其对经济绩效的影响和相应的公共政策，同时也研究不同产业之间的结构关系和经济技术关联及相应的产业政策。国内的产业经济学教学内容非常广泛，概括起来主要包括六大关系：产业组织主要研究产业内部企业与企业之间的关系；产业结构研究产业与产业之间的质的动态关系；产业关联着重研究产业与产业之间量的静态关系；产业布局研究产业与空间地理位置之间的关系；产业发展研究产业在整个国民经济进化过程中自身产生、成长和进化的关系，产业政策研究产业与政府之间的关系，为了弥补市场缺陷，有效配置资源而对产业的形成和发展进行干预或扶持政策。

通过产业经济学的学习，使学生掌握产业经济学的基本理论和产业组织的基本概念；熟悉产业结构分析框架和主要分析方法，能对现实经济中存在的大量产业组织现象和产业政策进行较深入的经济学分析；帮助学生从专业的角度解释、评价现实的产业经济实践问题和政策问题；帮助学生建立并拓展适应现实需要的产业政策方案设计能力和产业分析能力。

产业经济学是 19 世纪末期应用经济学领域的重要分支。在经济理论之外，产业经济学诞生的主要原因在于两个方面：经济理论不能对一些具体问题，如成本曲线、集中度等进行详细深入的经验研究；另外，经济理论不能对公共政策问题（反托拉斯法和公共规制领域）进行研究（Stigler,1968）。这些经济理论不能解决的具体而现实的问题就由产业经济学来解决。因此，产业经济学将从研究内容到教学实践，都充分围绕着应用性。

二、互联网经济背景下产业经济学教学改革的必要性

1、互联网发展对传统产业的改造

技术、资源、市场和产业都在互联网的影响下发生着巨大的改变。互联网与传统产业跨界融合更加广泛、深刻，传统产业也在向智能化、数字化、网络化纵深发展。互联网技术对传统产业的产品设计、生产流程、生产方式、产品销售等全过程渗透。传统产业通过互联网技术整合产业链上下游资源，加快生产流程创新与突破，对产业自身发展开辟了新的路径。产业之间也将以新的形式进行融合发展。例如农业由一次产业升级为由一次产业加二次产业加三次产业的六次产业。借助互联网的发展，利用新的技术、资源和融合方式把农业由一次产业升级为六次产业，不仅拓展了传统农业功能和社会收益，并且，使得这些功能和收益可以通过市场机制得以实现。新兴信息网络技术对生产性服务业的各个环节的渗透和扩散，催生出各种基于产业发展的服务新业态，生产性服务业将从技术应用、服务内容、商业模式等方面不断提升。互联网与传统产业的融合，不仅是对传统产业的改造升级，也将不断催生出新的产业形态，这些影响不仅体现在产业结构的变化、转型和升级方面，也会影响市场结构、竞争行为、盈利模式及市场绩效等方面，对产业组织产生深刻影响；对产业的空间布局及产业政策也将产生强烈冲击。因此，忽视这些新的变化，将无法对当下的产业经济现象进行更合理而深刻的解释，也难以对产业领域的现实问题做出有效的解决，产业经济学的应用性将难以体现。

2、互联网经济对市场和产业分布产生巨大影响

互联网经济使得传统理论下的很多规律发生改变。长尾理论（Long Tail）和众包（crowdsourcing）思维已经深入到传统产业的很多领域，市场细分越来越细，"个性化"、"客户力量"和"小利润大市场"概念正在广泛而深刻地影响着传统产业的市场结构和商业模式，处于需求曲线尾部的市场正在获得前所未有的关注和重视。影响市场结构的关键因素：集中度、差异化和进入退出壁垒也正在发生变化。市场中的竞争行为也随之变化，处于需求曲线头部的一级或者二级市场的占有率和利润率也正在经历由盛转衰。在互联网广泛应用之后，企业的营销活动也在发生着革命性的变化，营销活动受时空限制越来越少，营

销费用越来越低，营销结果越来越精准，广告方式越来越多样化，交易付费的广告付费方式使得广告费用大幅度缩减。这些互联网经济下市场、竞争策略、商业模式的变化应该被充分关注，融入产业经济学的日常教学之中。

电子商务发展促成产业空间分布新格局。电子商务纵向延展，促进城镇资源快速流转，横向跨境布局，促进全球消费市场的形成。与电子商务相关联的企业如软件公司、代运营工地、在线支付、物流公司等围绕电子商务企业进行聚集，也推动着传统产业集群升级。互联网与传统产业正在加速融合，推动产业集群向"在线产业带"转型。网络经济下的产业集聚现象越来越显著，与传统经济下的指向性集聚相比，经济联系性的聚集在加强，创新效益的分析也应该被进一步强化。

互联网经济下，传统产业为适应市场需求在不断转变，新的产业形态不断在催生，市场结构，消费需求和空间布局都在不断变化，新的现象和新的问题需要新的思维和新的理论，这对传统产业经济学理论是个挑战，也构成传统产业经济学教学改革的必要性。

三、互联网经济背景下产业经济学教学改革具体措施

1、教学理念的改革

产业经济学是现代经济学中用来分析现实经济问题的新兴的应用经济理论。学习本门课程的主要目的是使学生系统掌握产业结构、产业关联、产业组织，产业政策等基本理论，对目前产业的现状，问题及发展有一定的了解，并且能够独立的运用基本理论和概念分析我国目前产业经济当中的现状、问题、使理论和实践相统一。然而，互联网正在改变人们的消费习惯，市场环境，这些新的现象应该被引入课堂，这就要求在教学中必须摒弃单纯讲授传统理论的教学观念和对单一教材的依赖，结合网络资源和典型案例拓展学生在产业经济学领域的学科视野，强化学生发现、分析与解决市场经济中的实际问题的能力，突出学生在教学中的主体地位。

2、教学方法的改革

在网络经济时代，创新教学方法是产业经济学教学改革的重点。课堂上理论讲解、案例分析是基础，但是，让学生置身在市场和具体产业之中，才能更加深入的了解产业发展所面临的市场环境、竞争格局，行为策略以及政府规制等。在创新产业经济学课程教学过程中，探索教、学、用协同的产业经济学课外教学活动的组织形式，深化课堂教学。把"浸入式"的教学理念引入产业经济学的教学之中，让学生能够对某个产业的基本情况做调查研究，撰写调研报告等等；引导学生根据自己的兴趣和将来就业的意愿对具体产业进行追踪研究，并撰写行业分析报告；开展产业问题讨论，让学生能够把理论与现实问题相结合，深化对理论和现实的理解，并能够积极的寻求解决问题的方法和路径，提高学生的实际运用能力。

3、考核方法的改革

要贯彻教学方法的改革，考核方式必须相应的做以调整。单一闭卷考试形式不能充分反映学生对知识点的理解、掌握及运用情况，考核方式需要与教学方式相配合，多元化的考察学生实际运用相关概念和理论的能力，以及发现、关注产业经济现象与事实。例如，可以引导学生对互联网经济下产业市场结构、市场行为和市场绩效的变化，传统产业在互联网经济下面对的机遇与挑战，产业结构的重构、转型与升级，产业规制面临的新问题等进行讨论分析；让学生尝试撰写具体的产业经济案例和产业分析报告等。把考试与考察结合起来，更加全面的提升学生对产业经济学的理解和运用能力，增强知识的现实应用性。

4、教学材料的改革

网络经济下的产业经济学教学内容应该更加丰富。毋庸置疑，选择一本经典但又符合当下经济形势的好教材非常必要，但是，任何一本教材都有它的优缺点，为了扬长避短，更加丰富的学习材料和学习资源应该引入教学，包括经典案例，统计年鉴、行业报告、与课程内容相关的网络资源，以及与之相关的网络公开课程。多样化的教学材料不仅可以满足学生的课堂学习，而且可以作为课后辅助材料，开阔学生的视野，让学生更加充分的了解产业相关的知识和现实，让学生对产业经济学的内容形成综合知识结构体系，为其后续研究与应用奠定良好的理论基础和分析能力。

四、结论

产业经济学是现代经济学中用来分析现实经济问题的新兴的应用经济理论。要体现出它的应用性特征，就需要把握好经济运行所处的时代特征和市场环境，在大的背景下学习和研究产业的具体问题，产业经济学的教学不仅要注重经典概念和理论的讲授，更应该关注产业发展过程中出现的新现象和新问题；不仅要注重传统的产业经济学知识体系的完整性，更应该把现实中出现的新的突破性的变化引入教学内容，形成更具综合性和开放性的知识体系，增加产业经济学的应用性特征和学生对知识的实际运用能力。

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Explore the overall quality of college laboratory technician training

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Abstract: Laboratory of colleges and universities is an important part in experiment teaching and sci-entific research the experimental technical personnel´s overall quality not only decides the level of la-boratory construction but also will directly affect the quality of experiment teaching and scientific re-search work effect and the quality of personnel training should strengthen the cultivation of the com-prehensive quality of laboratory technical staff based on the analysis discusses the experimental techni-cal personnel should possess comprehensive quality and strengthening the experimental technical per-sonnel overall quality training countermeasures and suggestions.

Key words: colleges and universities; experiment and technical personnel; comprehensive quality

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Abstract: It is the key and difficult task for higher education to build the coordinated way of innovative education and profes-sional education, and to improve the breadth and depth of professional education and innovative education. The comprehensive talent training orientation provides the development path for the integration of innovation education and professional education. For this, we need to remodel college education´s target, to reconstruct college education system based on comprehensive talents, to revise the curriculum content, to strengthen teaching practice to cultivate students´ innovative ability, to change the separation relationship between professional education and innovation education.

Keywords: innovative education; professional education; comprehensive talents

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System Construction on Innovative and Entrepreneurial Education

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Abstract : It is different from professional education that innovative and entrepreneurial education need to change traditional lecturing into training innovation sense,stimulating students' creative interest and developing student's creative potential. Innovative and entrepreneurial education in universities should establish education system platform of innovative and entrepreneurial education. Universities can make efforts in aspects of enriching education curriculum, improving teaching methods,strengthening education practice and training teachers team for innovative and entrepreneurial education building.

Key words : innovative education;professional education;entrepreneurial education

2. 科研成果

2.1 承担科研项目

表 2-1 经济管理实验教学中心人员科研项目——国家级

序号	项目名称	项目编号	项目类别	项目负责人	开始期	结束期	项目经费（万元）
1	"农超对接"模式效率评价及效率提升机制研究	71173176	国家自然科学基金	刘天军	2012-01	2015-12	43
2	跨区域输水中水源地生态服务价值损失评估与补偿标准研究--以京津与冀北山区间跨区域输水为例	71103144	国家自然科学基金	宋健峰	2012-01	2014-12	21
3	集体林权改革背景下南方农户商品林生产要素配置效率及其提升路径研究	71273211	国家自然科学基金	李 桦	2013-01	2016-12	54
4	农民专业合作社纵向一体化研究	13BJY106	国家社科基金项目	王礼力	2013-07	2015-07	18
5	西北地区水资源配置的多目标协同研究：全价值评估与公众支持	71373209	国家自然科学基金	赵敏娟	2014-01	2017-12	58
6	基于农户收入质量的农村正规信贷约束模拟检验及政策改进研究	71373205	国家自然科学基金	孔 荣	2014-01	2017-12	56
7	基于资源环境禀赋视角的生态修复工程补偿标准研究	71373206	国家自然科学基金	郭亚军	2014-01	2017-12	56

8	融合重力模拟机制和地表几何形态的DEM地形分析矢量方法研究	41301507	国家自然科学基金	晋蓓	2014-01	2016-12	25
9	基于农户异质性视角的农业环境全要素生产率增长分析及提升机制研究	71303188	国家自然科学基金	白秀广	2014-01	2016-12	19
10	黑河流域农业水资源模型数据收集、计算、分析与模型测试分析	91325302	国家自然科学基金	赵敏娟	2014-07	2016-07	12
11	西部农户非木质林产品经营行为选择及效率提升路径研究：基于家庭劳动力配置视角	71403212	国家自然科学基金	薛彩霞	2015-01	2017-12	23
12	基于双内生视角的非农就业对林地流转的影响研究——以福建、江西、云南集体林区为例	71403213	国家自然科学基金	张寒	2015-01	2017-12	22
13	基于利益主体契约选择与关系视角的生猪产销纵向协作整合治理研究	71403210	国家自然科学基金	徐家鹏	2015-01	2017-12	20
14	基于普惠金融视角的P2P网络借贷绩效评价及其制度优化路径研究	71403215	国家自然科学基金	杨虎锋	2015-01	2017-12	20
15	少数民族社会-生态系统对气候变化的响应与适应机制研究--基于云南哈尼族农村社	71403209	国家自然科学基金	骆耀峰	2015-01	2017-12	19

	区的数据						
16	生态文明建设背景下自然资源治理体系构建：全价值与多中心途径	15ZDA052	国家社会科学基金	赵敏娟	2015-07	2017-06	80
17	生计资本视角下西北地区生态移民政策的收入效应及优化路径研究	71503202	国家自然科学基金	陈晓楠	2016-01	2018-12	19
18	社会网络与培训服务对地方特色农产品保险需求的影响研究——以陕西、甘肃苹果保险为例	71503203	国家自然科学基金	罗添元	2016-01	2018-12	18
19	异质性农户农用化学品减量投入及其替代品使用促进政策研究	16BGL135	国家社会科学基金	王永强	2017-01	2018-12	20
20	基于社会规范和个人规范双重视角的农户亲环境行为——作用路径及提升机制	17BJY067	国家社科一般项目	李世平	2017-01	2018-12	20
21	空间变参数成矿预测信息综合模型研究	41602336	国家自然科学基金	张道军	2017-01	2019-12	18
22	农地经营权抵押贷款信贷约束检验与模式优化研究——基于农户分化视角	71603208	国家自然科学基金	牛　荣	2017-01	2019-12	17
23	苹果矮化集约栽培制度创新及效率：与传统制度比较视角的理论与实证分析	71603207	国家自然科学基金	邵砾群	2017-01	2019-12	17

24	金融行为中介作用下农民金融素养对收入质量的影响机制及提升策略研究	71773094	国家自然科学基金面上项目	孔　荣	2018-01	2021-12	49
25	农户参与农田灌溉系统管护研究：资源禀赋、组织支持与治理绩效	71773092	国家自然科学基金面上项目	朱玉春	2018-01	2021-12	49
26	信任与农民创业：机会识别、创业决策与创业绩效	71773089	国家自然科学基金面上项目	刘天军	2018-01	2021-12	48
27	权属来源、用途特性、经营规模视角下农地经营权抵押约束的实证研究	71773090	国家自然科学基金面上项目	李　韬	2018-01	2021-12	43
28	电商模式下基于成熟度的鲜果采摘与发货联合决策研究	71703122	国家自然科学基金青年科学基金项目	阮俊虎	2018-01	2020-12	18
29	基于Copula方法的西北地区农业天气风险管理研究	71703123	国家自然科学基金青年科学基金项目	冀　昊	2018-01	2020-12	18
30	地理标志引导农户绿色生产机制研究	18XJY007	国家社会科学基金一般项目	李　桦	2018-06	2021-05	20
31	集体林权制度改革对农户营林投入的影响机理及效应评价——基于非农就业和要素替代的双重视角	71873099	国家自然科学基金面上项目	张　寒	2019-01	2022-12	49
32	环境意识与技能对农户亲环境行为的影响机理与政策优化研究：以	71873102	国家自然科学基金面上项目	薛彩霞	2019-01	2022-12	47

序号	项目名称	项目编号	项目类别	项目负责人	开始期	结束期	项目经费（万元）
	秦巴山区非木质林产品生产为例						
33	线上线下融合背景下生鲜电商与线下店铺的竞合策略研究	71803152	国家自然科学基金青年科学基金项目	李政道	2019-01	2021-12	17

表 2-2 经济管理实验教学中心人员科研项目——省部级

序号	项目名称	项目编号	项目类别	项目负责人	开始期	结束期	项目经费（万元）
1	"西北旱区农业水资源潜力与高校利用模式集成及应用"子课题"典型灌区农业节水激励机制与节水效应研究"	2011BAD29B09-1-7	科技部	宋健峰	2011-01	2015-12	10
2	蔬菜产业固定观测点的建立及相关数据的采集	k3070211 01	农业部	徐家鹏	2011-03	2015-12	5
3	建立蔬菜产业固定观察点及相关数据调查与采集	K3070211 02	农业部科技项目	胡华平	2011-03	2018-12	11
4	新形势下劳动力外出务工对农户农业生产的影响及对策研究——基于新迁移经济学理论	12YJC790 212	教育部	徐家鹏	2012-01	2015-12	7
5	陕西省森林碳汇抵押融资机制研究	2013KW-18-02	陕西省科技厅	杨文杰	2013-01	2014-12	5
6	商业性小额贷款公司的信贷供给：	13YJC790 177	教育部	杨虎锋	2013-07	2015-12	8

	运作机制及绩效评价研究						
7	集体林权改革背景下西部农户林地经营行为及效率提升路径研究——以四川省农户为例	13YJC630194	教育部人文社科项目	薛彩霞	2013-09	2016-09	8
8	西部地区农户收入质量、信贷需求与农村正规信贷约束的联动影响研究	20120204110035	教育部	孔 荣	2013-10	2015-12	8
9	陕西新型果农合作社发展及培育研究	2014KRM55	陕西省科技厅	邵砾群	2014-01	2015-12	3
10	基于抵押品的西北地区森林碳汇贷款机制研究	2014-R12	国家林业局	杨文杰	2014-01	2016-12	20
11	国内种子企业发展态势	201401070376	农业部	李 桦	2014-01	2015-10	10
12	我国集体林产权改革配套改革效果与政策分析	K403021414	国家林业局	李 桦	2014-08	2014-12	5
13	基于集成创新理论的陕西现代农业园区创新能力研究	2014D46	陕西省哲学社会科学规划办	雷 玲	2014-09	2016-10	1
14	基于双内生视角的非农就业对林地流转的影响研究——以福建、江西集体林区为例	14YJC790166	教育部人文社科项目	张 寒	2015-01	2017-12	8
15	陕西省集体林地流转的影响因素研究——基于双内生决策变量视角	2014JQ2-7043	陕西省科技厅自然科学基础研究计划	张 寒	2015-01	2016-12	2

16	农业产业化和农产品质量安全：农业标准形成与作用机理	D201525	农业部	邵砾群	2015-05	2015-12	5
17	陕西省农业"走出去"重点产业与合作模式研究	201501071358	农业部对外经济研究中心	刘天军	2015-06	2016-06	5
18	国有林场改革背景下森林公园管理机制与模式创新研究	2015-R31	国家林业局	邵砾群	2015-07	2016-12	5
19	公众参与的生鲜食品全产业链质量安全监督促进机制研究	2015D016	陕西省哲学社会科学规划办公室	王永强	2015-09	2017-09	1.5
20	基于博弈论的陕西省家庭农场融资可得性研究	2015R027	陕西省哲学社会科学规划办公室	宋健峰	2015-09	2017-09	1.5
21	基于分化视角的陕西省农户借贷需求研究	201502041470	陕西省社会科学基金项目	牛　荣	2015-09	2017-09	1.5
22	领导者心理契约对下属的影响机理研究	15YJC630029	教育部人文社会科学研究项目青年基金项目	韩　樱	2015-10	2017-12	8
23	农户农地经营权反担保贷款可得性研究：机理、实证与对策	15XJC790004	教育部人文社科项目	李　韬	2015-10	2018-10	8
24	天然林保护工程财政资金投资绩效评价方法研究	201603030033	国家林业局横向-技术咨询	赵敏娟	2015-12	2016-12	10
25	考虑成熟度的鲜果B2C电商物流配送优化研究-以陕西省猕猴桃为	16YJC630102	教育部人文社科项目	阮俊虎	2016-01	2018-12	5

	例						
26	陕西农村小微企业组织创新动因识别及矩阵式战略体系设计——基于企业生命周期视角	2016KRM075	陕西省科技厅	梁洪松	2016-01	2016-12	5
27	退耕还林工程可持续性背景下黄土高原不同退耕规模农户收入增长及其差异的影响研究	2016KRM068	陕西省科技厅	李 桦	2016-01	2018-12	5
28	鲜果B2C电商物流配送路线优化及干扰管理研究-以陕西省为例	2016JQ7005	陕西省科技厅	阮俊虎	2016-01	2017-12	3
29	基于水足迹的陕西省农业生态效率评价	2016JQ7001	陕西省科技厅	宋健峰	2016-01	2017-12	3
30	陕北黄土高原区农地规模流转适宜性评价与提速策略研究	2016JQ7003	陕西省科技厅	陈 伟	2016-01	2017-12	3
31	涉农企业上市成长路径研究	2014GXS3D044	科技部	赵敏娟	2016-01	2016-12	20
32	陕西省现代农业发展模式与实现路径研究	2016ZDA14	陕西省哲学社会科学规划办	赵敏娟	2016-03	2016-12	20
33	陕南生态移民生计资本变迁及优化策略研究	2016Z109	陕西省社科界2016年度重大理论与现实问题研究项目	陈晓楠	2016-06	2017-05	0.7
34	组织形式、生产者行为与农产品质量激励研究——	2016Z014	陕西省社科界2016年度重大	张晓宁	2016-06	2017-06	0.7

	以陕西为例		理论与现实问题研究项目				
35	农业人力资本投资供给侧改革影响因素及模式创新研究——以西北5省新型经营主体为例	16XJA790005	教育部人文社科项目	刘　超	2016-07	2019-07	9
36	基于诱致性变迁理论的农业技术创新及效率：以苹果矮化集约栽培技术为案例的实证研究	16YJC630085	教育部人文社科项目	邵砾群	2016-07	2019-07	8
37	农业区域品牌的运营机制与推广策略研究：基于合作社视角	16YJC630050	教育部人文社科项目	李大垒	2016-07	2019-07	8
38	西北地区新生代农民工创业绩效研究-社会资本和心理资本双重视角	16YJC630072	教育部人文社科项目	马红玉	2016-07	2019-07	8
39	"互联网+"背景下苹果种植户安全生产行为研究：交易成本、农户认知与行为决策	16XJA790006	教育部人文社科项目	刘天军	2016-07	2019-07	10
40	基于空间加权技术的成矿预测信息综合模型研究	K308021 6015	中国博士后科学基金第59批面上二等资助	张道军	2016-08	2017-08	5
41	多增长极培育的陕西省区域经济协调发展研究	2016D039	陕西省哲学社会科学规划办	崔永红	2016-09	2018-09	2
42	陕西省政策性农业保险发展研究	2016D020	陕西省哲学社会科	姬便便	2016-09	2018-09	2

			学规划办				
43	社会资本、心理资本对新生代农民工创业行为影响研究-以陕西省为例	2016D012	陕西省哲学社会科学规划办	马红玉	2016-09	2018-09	2
44	轻资产生鲜O2O模式下的终端库存控制策略和协调机制研究	17XJC630005	教育部人文社科青年基金	李政道	2017-01	2018-12	8
45	西北旱区大型灌区灌溉用水反弹效应研究	17YJC790126	教育部人文社科青年基金项目	宋健峰	2017-01	2018-12	8
46	林业人力资本投资供给侧改革影响因素及模式创新研究	2017-R25	林业局软科学	刘　超	2017-01	2018-12	5
47	现代农业产业体系荞麦产业经济	K336021503	现代农业产业体系	赵敏娟	2017-01	2023-12	490
48	基于空间计量模型的陕北黄土高原退耕还林驱动力分析和实施评价	2017JQ7010	陕西省科技厅自然基金	张道军	2017-01	2018-12	3
49	创业资本对新生代农民工创业行为作用机理研究-以陕西省为例	2017KRM130	陕西省科技厅创新能力支撑计划	马红玉	2017-01	2018-12	3
50	基于效率视角的陕西农业化肥减施增效及其提升机制研究	2017S018	陕西社科一般项目	白秀广	2017-01	2018-12	2
51	气候变化、适应性对粮食作物生产的影响：收益、产量及全要素生产率	17YJA790003	教育部人文社科规划基金项目	白秀广	2017-01	2018-12	10

52	现代农业燕麦荞麦产业经济	201709130 00001	现代农业产业技术体系	赵敏娟	2017-05	2020-12	70
53	集体林权制度改革监测：完善集体林权制度第三方评估研究方案	2017FMA-9	林业局软科学	杨 峰	2017-07	2018-05	18
54	多元经营主体格局下耕地休耕的影响机理及优化调控研究	18YJCZH 049	教育部人文社科青年基金	侯现慧	2018-01	2020-12	8
55	宏观审慎监管框架下系统性金融风险目标导向预警指标体系构建及溢出效应测度研究	18YJC910 011	教育部人文社科青年基金	田茂茜	2018-01	2020-12	8
56	金融素养对农户金融资产配置决策的影响机制及提升策略研究	18YJC790 053	教育部人文社科青年基金	胡振	2018-01	2020-12	8
57	城镇超重肥胖居民的食物消费需求研究：行为分析与政策干预	18YJC790 231	教育部人文社科青年基金	赵殷钰	2018-01	2020-12	7.98
58	陕南秦巴山区旅游产业-城镇化-生态环境耦合协调发展研究	2018KRM 017	陕西省软科学	徐家鹏	2018-01	2019-12	5
59	陕西省重点生态功能区跨区域补偿体系研究	2018KRM 011	陕西省软科学	孟全省	2018-01	2019-12	5
60	农村土地流转对耕地轮作休耕的影响研究——以陕西省典型区为例	2018JQ70 05	陕西省自然科学基金	侯现慧	2018-01	2019-12	3
61	西安市鄠邑区葡	2018KRM	陕西省软	薛彩霞	2018-01	2019-12	3

	萄产业可持续发展水平及提升路径研究	089	科学				
62	集体林权制度改革对农户营林投入的影响研究：基于产权激励、劳动配置和要素替代的视角	18YJA790104	教育部人文社科规划基金	张　寒	2018-01	2020-12	10
63	秦巴山区非木质林产品生产农户亲环境行为研究：基于环境意识与环境技能视角	18YJA630124	教育部人文社科规划基金	薛彩霞	2018-01	2020-12	10
64	环境意识与技能对秦巴山区农户非木质林产品生产亲环境行为影响研究	2018S33	陕西省社科一般项目	薛彩霞	2018-05	2020-10	2
65	劳动力迁移下陕南农村地区留守老人多维贫困测度、分解及扶贫对策	2018D34	陕西省社科一般项目	徐家鹏	2018-05	2020-10	2
66	陕西省农村居民金融素养及其对金融资产配置的影响机制及优化路径研究	2018S19	陕西省社科一般项目	胡　振	2018-05	2020-10	2
67	气候变化对新疆棉花生产的影响研究	20180928000006	现代农业产业技术体系	胡　振	2018-10	2019-09	10

表 2-3 经济管理实验教学中心人员科研项目——厅局级

序号	项目名称	项目编号	项目类别	项目负责人	开始期	结束期	项目经费（万元）
1	陕西省质量强省发展战略研究	201302041151	陕西省厅局项目	赵晓锋	2013-07	2014-07	4
2	陕西省现代产业发展新体系构建研究	2013z071	陕西省厅局项目	张晓宁	2013-07	2014-07	0.6
3	中国旱区农业技术发展研究	K33602130201500	科研项目	刘天军	2013-09	2019-12	180
4	中职师资培训包会计专业开发研究	ZZPXB03	陕西省厅局项目	孟全省	2014-01	2014-12	20
5	技术接近、地理位置与产业集聚的技术溢出效应研究	13HQ020	陕西省厅局项目	张晓宁	2014-01	2014-12	1.5
6	陕西与丝绸之路沿线国家在农业科技方面的合作：基于杨凌示范区的作用研究	13SC023	陕西省厅局项目	李 韬	2014-04	2014-12	1
7	陕西省政策性农业保险绩效评价	201599991054	纵向协作	姬便便	2014-06	2015-06	20
8	杨凌示范区实施科技创新驱动战略研究	2014RKX/08	杨凌示范区科学技术局	赵敏娟	2014-10	2019-09	3
9	基于旱区农业技术创新能力提升的农科教结合创新机制研究	2015RKX-11	杨凌示范区	王永强	2015-01	2017-12	3
10	基于集成创新理论的杨凌现代农	2015RKX-04	杨凌农业高新技术	雷 玲	2015-01	2017-12	3

		产业示范区科学技术局					
	业园区创新能力研究						
11	杨凌示范区科技创新：效率测定、绩效评估及策略选择	2015RKX-09	杨凌农业高新技术产业示范区科学技术局	孔 荣	2015-01	2017-12	3
12	杨凌示范区科技创新资源优化配置研究	2015RKX-07	杨凌示范区	梁洪松	2015-01	2017-12	3
13	碳减排单边政策下多级供应链运作分析及协同减排策略研究	2014JQ2-7040	陕西省财政厅	李政道	2015-01	2016-12	2
14	农产品流通体系机制创新研究	201516001359	陕西省教育厅"青年英才支持计划"	刘天军	2015-01	2018-12	11
15	杨凌示范区百亿元产业集群发展规划	YLZFCG2015DY22	杨凌农业高新技术产业示范区管委会	孙养学	2015-05	2016-12	17
16	中国农业产业投资报告	201516001361	杨凌示范区财政省内县市科技局项目	刘天军	2015-06	2016-06	30
17	旱区农业科技资源配置效率与区域协同机制研究	2015KRM077	陕西省财政厅	胡华平	2015-06	2016-05	3
18	杨凌示范区成品油行业十三五及特色美食街发展规划	201603030040	杨凌农业高新技术产业示范区经贸发展局	王永强	2015-06	2016-04	10
19	陕西省集体林地流转的影响因素与优化路径研究	201516001462	陕西省厅局项目	张 寒	2015-06	2016-06	1

	——基于双内生农户决策模型						
20	中国农业产业投资研究		杨凌示范区	刘天军	2016-01	2016-12	30
21	杨凌示范区商业网点规划	201603010092	杨凌示范区经贸发展局横向-技术服务	刘天军	2016-01	2016-12	23
22	陕西高校人文社会科学青年英才支持计划	201601010159	陕西省教育厅	李 桦	2016-01	2019-12	12
23	"互联网+"环境下生鲜电商物流模式对比与优化设计	2016RKX-04	杨凌示范区软科学计划研究项目	阮俊虎	2017-01	2018-12	4
24	农地流转背景下杨凌示范区新型农业经营主体金融支持研究	2017RKX-02	杨凌示范区软科学计划研究项目	李 韬	2017-01	2018-12	4
25	杨凌示范区创新驱动发展核心载体培育研究	2016RKX-05	杨凌示范区软科学计划研究项目	张晓宁	2017-01	2018-12	4
26	陕西省保险业参与精准扶贫效果研究	sbx20181204	陕西省保险学会研究课题	姬便便	2018-06	2019-04	0.2
27	农业科技服务引导农户绿色生产机制研究	2018RKX-12	杨凌软科学	李 桦	2018-07	2020-06	4
28	杨凌示范区良种产业化模式研究	2018RKX-02	杨凌软科学	杨文杰	2018-07	2020-06	4
29	杨凌示范区农业风险管理创新机制研究——基于农业保险需求视角	2018RKX-04	杨凌软科学	赵殷钰	2018-07	2020-06	4

序号	项目名称	项目编号	项目类别	项目负责人	开始期	结束期	项目经费（万元）
30	杨凌示范区农业企业孵化器运行机制及效用评价研究	2018RKX-07	杨凌软科学	梁洪松	2018-07	2020-06	4
31	杨凌土地流转模式研究	2018RKX-08	杨凌软科学	牛　荣	2018-07	2020-06	4

表 2-4 经济管理实验教学中心人员科研项目——横向

序号	项目名称	项目编号	项目类别	项目负责人	开始期	结束期	项目经费（万元）
1	农村工作标准体系研究	2012030100834	横向-技术服务	孟全省	2012-01	2014-12	2
2	榆林市水稻产业发展规划	2013030110205	横向-技术服务	王秀娟	2013-06	2014-03	38
3	西安市耕地与基本农田保护研究	2015030100009	横向-技术服务	李世平	2014-01	2015-06	26.35
4	世界知名农业科技创新城市研究	2015030100056	横向-技术服务	刘天军	2014-04	2015-12	22
5	生态工程经济与社会效益与生态修复的互馈效应	KFJ-EW-STS-005-03-03	中国科学研究院	赵敏娟	2014-05	2015-12	12
6	大宗淡水鱼产业技术效率与预警问题研究	2014030300306	横向-技术咨询	赵敏娟	2014-06	2014-12	12
7	我国集体林产权制度配套改革效果评估与政策分析	JYC2014-41	横向-技术服务	李　桦	2014-08	2014-12	5
8	蒲城现代农业园区果业规划设计		其它	刘天军	2014-09	2015-09	3

9	陕西省太白林业局林业产业发展研究	201416000618	其它	孟全省	2014-09	2015-06	19.6
10	杨凌示范区金融生态环境评价研究	201503010057	横向-技术服务	刘天军	2014-09	2015-09	1.8
11	千阳县"十三五"水资源供需与水利事业发展研究报告	201403010708	横向-技术服务	赵敏娟	2014-11	2014-12	20
12	2015年度民和县小规模土地开发（占补平衡）项目实施方案TDKF-2015-(02~07)	201711 09 000002	横向	张道军	2015-01	2017-11	48
13	亚行贷款兰州城市交通项目移民安置能力建设咨询服务	201603030086	亚行贷款兰州城市交通项目办公室	陈晓楠	2015-05	2017-12	32
14	工业用地利用效率研究：时空特征与提升能力建设	201501040212	子课题	陈 伟	2015-05	2017-05	10.39
15	田东金融扶贫模式研究	201503031428	中国农业大学	杨虎锋	2015-06	2018-05	5
16	山阳高坝农特产品物流中心可行性报告	201503030197	横向-技术咨询	王永强	2015-08	2015-09	27
17	子洲县2014年-2020年山地苹果产业发展规划研究	201503031357	子洲县财政局横向-技术咨询	刘天军	2015-09	2016-09	25
18	甘肃景泰黄崖坝现代农业示范园区总体规划	201603030039	景泰县农牧局横向-技术咨询	王永强	2015-12	2016-04	13
19	2016年度民和县小规模土地开发（占补平衡）项目	201711 08 000001	横向	张道军	2016-01	2017-11	64

	实施方案 TDKF-2016-(01~08)						
20	靖边县现代葡萄产业发展总体规划	201716000569	横向项目	刘天军	2016-01	2017-12	4.4
21	杨凌示范区大学城发展研究	2016030100099	横向项目	孙养学	2016-03	2016-10	6
22	我国城市行政中心迁移研究	2016MZRL014-06	横向项目	晋 蓓	2016-04	2016-10	5
23	小杂粮（荞麦）的生产和销售价值评估	201612190000006	横向	赵敏娟	2016-09	2016-12	6.22
24	平安区洪水泉乡高标准基本农田整理项目规划设计与预算编制工作	201711290000001	横向	张道军	2016-12	2017-11	58.69
25	陕西省陕北绒三羊工程技术研究中心——榆林	17100000337	横向	杨文杰	2017-01	2018-12	53
26	陕西农产品商标品牌发展指数报告	K4030218271	横向	赵敏娟	2017-01	2017-11	44
27	我国苹果现货报告课题	20170508000001	横向	刘天军	2017-03	2017-05	20
28	扶风县现代苹果产业发展规划	20170508000002	横向	刘天军	2017-04	2017-06	25
29	小杂粮（荞麦）的生产和销售价值评估	201810190000019	横向	赵敏娟	2018	2019	12.17
30	武山县县域经济发展规划	201803200000011	横向	刘军弟	2018-01	2018-06	6
31	贫困精准退出标准	K4030218046	横向	李 桦	2018-01	2018-06	5

表 2-5 经济管理实验教学中心人员科研项目——校内

序号	项目名称	项目编号	项目类别	项目负责人	开始期	结束期	项目经费（万元）
1	粮食价格形成机制与现代粮食流通体系建设研究	2011RWZX02-1	校人文社科专项	姬便便	2011-01	2014-12	1
2	农户对气候变化的适应机制研究	2011RWZX03-4	校人文社科专项	陈晓楠	2011-01	2014-12	1
3	气候变化对区域农业生产和空间分布的影响	2011RWZX03-2	校人文社科专项	雷 玲	2011-01	2014-12	1
4	食品供应链体系全程管理方法及效率评价	2011RWZX01-3	校人文社科专项	庞晓玲	2011-01	2014-12	1
5	我国食品安全认证制度研究	2011RWZX01-2	校人文社科专项	邵砾群	2011-01	2014-12	1
6	我国食品供应体系管理的制度框架研究	2011RWZX01-1	校人文社科专项	董春柳	2011-01	2014-12	1
7	黄土高原生态恢复工程与农业生产力变化关系研究	QN201116 8	基本科研业务费	李 桦	2011-01	2014-12	3
8	中国苹果产业龙头企业组织创新动因与模式研究——以黄土高原优势区苹果产业为例	QN201116 4	基本科研业务费	梁洪松	2011-01	2014-12	3
9	西北地区农地使用权流转典型分析及其均衡规模研究	QN201104 6	基本科研业务费	赵敏娟	2011-07	2014-07	9
10	城郊农地流转背景下生鲜农产品流通模式、效率及其演变研究	Z1090211 16	博士科研启动基金	胡华平	2011-10	2014-10	3
11	中国苹果产业龙头企业组织创新动因		基本科研业务费	梁洪松	2011-10	2014-10	8

	与模式研究——以环渤海湾、黄土高原优势区苹果产业为例						
12	农产品供应链中生产与物流系统集成优化方法研究	Z109021110	博士科研启动基金	李政道	2012-01	2014-12	3
13	农户环境友好型技术采纳行为、机理及生态补偿机制研究-以测土配方施肥技术为例	QN2012050	基本科研业务费	白秀广	2012-04	2015-04	6
14	陕西资源型城市产业演变机理研究－基于能值理论	QN2012052	基本科研业务费	刘　超	2012-04	2015-04	6
15	关中地区无公害设施农业基地建设研究	2012RWZX03	校人文社科专项	张雯佳	2012-07	2014-07	4
16	农民不安全农药使用行为控制机制研究	2012RWZX01	校人文社科专项	王永强	2012-07	2014-07	4
17	农业结构调整对我国西部农户增收及收入差距的影响研究	2012RWZX07	校人文社科专项	赵晓锋	2012-07	2014-07	4
18	西部地区农户收入质量、信贷需求与农村正规信贷约束的联动影响研究	2012RWZD02	校人文社科专项	孔　荣	2012-07	2014-07	8
19	脆弱性贫困、食物消费行为与农村老年人健康质量的关联研究	2013RWZD02	2013基本科研业务费人文社科专项	赵敏娟	2013-01	2015-12	10
20	产业链组织模式对农户安全农产品生产影响研究	2013RWYB06	2013基本科研业务费人文社科专项	张　会	2013-01	2015-12	5
21	新型城镇化背景下	2013RWY	2013基本	王秀娟	2013-01	2015-12	5

	西北地区城乡蔬菜价格联动机制研究	B07	科研业务费人文社科专项				
22	政府规制下西部农户林地经营行为选择及效率提升路径研究——以四川省农户为例	2013RWYB05	2013基本科研业务费人文社科专项	薛彩霞	2013-01	2015-12	5
23	苹果产业价值链价值增值及其对农户的影响研究	QN201309 1	基本科研业务费	刘天军	2013-03	2015-12	10
24	博士科研启动费	Z1110213 11	博士科研启动基金	李 韬	2013-06	2016-06	3
25	欧盟水果的市场保护及中国苹果的国际市场潜力研究	2013BSJJ 029	2013年博士科研启动费	赵晓锋	2014-01	2015-12	2
26	产业链组织模式对苹果种植户安全生产行为影响研究	2013BSJJ 021	2013年博士科研启动费	张 会	2014-01	2015-12	3
27	雇佣关系的"共赢"管理——基于心理契约理论的研究	2013BSJJ 028	2013年博士科研启动费	韩 樱	2014-01	2015-12	3
28	管理者在职消费问题研究——基于经济权力交易理论的分析视角	2013BSJJ 027	2013年博士科研启动费	赵珏航	2014-01	2015-12	3
29	基于产业链的蔬菜价格传导研究	2013BSJJ 024	2013年博士科研启动费	姜雅莉	2014-01	2015-12	3
30	基于遥感和GIS的杨凌区农村居民点的空间格局演变与驱动力研究	60252202 52210112	博士科研启动基金	晋 蓓	2014-01	2016-12	3
31	陕西省专业农户融资需求与农村金融服务优化研究	2013BSJJ 023	2013年博士科研启动费	牛 荣	2014-01	2015-12	3
32	生产者对食品安全管理制度的行为影	2013BSJJ 025	2013年博士科研启	王永强	2014-01	2015-12	3

			动费				
33	基于双内生视角的非农就业对林地流转的影响研究——以福建集体林区为例	2014RWYB02	2014基本科研业务费人文社科专项	张 寒	2014-05	2017-05	5
34	陕西省家庭农场形成机制与运行效率研究	2014RWYB03	校人文社科专项	邵砾群	2014-05	2017-05	5
35	我国生猪价格剧烈波动与政策调控有效性研究——基于开放经济DSGE模型	2014RWYB04	2014基本科研业务费人文社科专项	胡华平	2014-05	2017-05	5
36	西部农户非木质林产品经营效率研究：基于家庭劳动力配置视角	2014BSJJ083	2014年博士科研启动费	薛彩霞	2015-01	2016-12	3
37	基于结构方程模型的陕西省农户金融资产选择研究	2015RWYB02	2015基本科研业务费人文社科专项	宋健峰	2015-01	2017-12	4.7
38	组织形式、生产者行为与农产品质量激励研究	2015RWYB03	2015基本科研业务费人文社科专项	张晓宁	2015-01	2017-12	4.7
39	分化视角下陕西省不同规模种植农户融资需求研究	2015RWYB08	2015基本科研业务费人文社科专项	牛 荣	2015-01	2017-12	5
40	基于多保障水平的地方特色农产品保险支付意愿研究——以陕西苹果保险为例	2015RWYB07	2015基本科研业务费人文社科专项	罗添元	2015-01	2017-12	5
41	基于生计资本框架的陕南移民政策评价及优化研究	2015RWYB05	2015基本科研业务费人文社科专项	陈晓楠	2015-01	2017-12	5

42	农户农地经营权反担保贷款可得性研究	2015RWYB06	2015基本科研业务费人文社科专项	李 韬	2015-01	2017-12	5
43	养殖户疫情脆弱性测评、形成机制及适应策略研究	2015RWYB04	2015基本科研业务费人文社科专项	党红敏	2015-01	2017-12	5
44	气候变化对苹果生产的影响研究	245201545 6	2015年第二批基本科研业务费青年培育专项	白秀广	2015-08	2015-12	4
45	陕西省耕地非农流转的量质特征与分区管制研究	245201523 1	2015年第二批基本科研业务费科技创新专项	陈 伟	2015-08	2015-12	4
46	水污染群体事件参与主体的心理感知测度与行为引导方法研究	245201523 0	2015年第二批基本科研业务费科技创新专项	阮俊虎	2015-08	2015-12	4
47	基于空间变量结构特征的土地资源评价模型改进	245201532 6	2015年第一批博士科研启动基金	张道军	2015-09	2018-08	10
48	鲜果B2C电商物流配送路线优化及其干扰管理研究-以陕西省猕猴桃为例	245201532 5	2015年第一批博士科研启动基金	阮俊虎	2015-09	2017-08	10
49	现代农业生产经营创新模式与粮食安全研究：以西北、华北和东北为例	245201532 8	2015年第一批博士科研启动基金	丁吉萍	2015-09	2018-08	10
50	基于需求视角的农业技术进步采纳效应评价研究——以苹果矮砧密植栽培	245201532 2	2015年第一批博士科研启动基金	邵砾群	2015-09	2018-08	3

	模式为例						
51	陕北黄土高原区农地规模流转适宜性评价与提速策略研究	245201532 3	2015年第一批博士科研启动基金	陈　伟	2015-09	2018-08	3
52	基于非正态市场的投资组合最优化模型改进	245201616 0	2016年博士科研启动费	冀　昊	2016-05	2017-12	10
53	黄土高原退耕还林可持续激励政策研究	2016RKX 03	西农软科学	李　桦	2016-05	2016-12	5
54	让生鲜O2O安全落地——基于便利店的终端配送优化和协同运作策略研究	2016RWY B01	2016基本科研业务费人文社科专项	李政道	2016-05	2017-05	5
55	新生代农民工社会资本、心理资本与创业绩效关系研究-以陕西省为例	2016RWY B02	2016基本科研业务费人文社科专项	马红玉	2016-05	2017-05	5
56	金融素养对家庭金融资产配置的影响研究	245201720 00	博士科研启动费	胡　振	2017-05	2019-09	10
57	陕西省农产品加工小微企业成长影响研究："双创"环境异质性及资源整合能力	2017RWY B09	基本科研业务费	梁洪松	2017-05	2019-05	10
58	中国肥胖人群的食物消费行为特点及成因研究	245201704 0	博士科研启动费	赵殷钰	2017-05	2019-07	10
59	新生代农民工创业绩效影响因素及提升路径研究	245201700 9	博士科研启动费	马红玉	2017-05	2019-06	3
60	产业扩散、地价异变与城市工业用地配置	2017RWY B01	基本科研业务费	陈　伟	2017-05	2019-05	5
61	金融素养对农户正规金融借贷行为影	2017RWY B07	基本科研业务费	杨虎锋	2017-05	2019-05	5

	响研究						
62	面向空间扩张互侵过程的土地生态安全动态评价—以陕西省泾阳县为例	2017RWYB04	基本科研业务费	晋 蓓	2017-05	2019-05	5
63	生态退耕对区域耕地产能的影响研究——以陕北黄土高原为例	2017RWYB08	基本科研业务费	张道军	2017-05	2019-05	5
64	青年卓越人才	2452017027	专项	赵敏娟	2017-05	2018-05	50
65	贫困地区产业融合：以凉山苦荞价值链提升为例	2017RWYB11	基本科研业务费	赵敏娟	2017-05	2018-05	6
66	集体林权制度改革对农户林地投入的影响研究——基于非农就业的视角	2018RWSK06	基本科研业务费项目	张 寒	2018-04	2020-04	5
67	农地流转背景下新型农业经营主体金融支持研究	2018RWSK03	基本科研业务费项目	李 韬	2018-04	2020-04	5
68	世界荞麦贸易格局及对我国荞麦产业发展影响研究	2018RWSK08	基本科研业务费项目	赵敏娟	2018-04	2019-04	6
69	基于化肥利用效率视角的异质性农户化肥减施增效及其提升机制研究	2018RWSK01	基本科研业务费项目	白秀广	2018-04	2020-04	9.5
70	水果种植户对跨境电商的认知意愿及其海外仓补货批量优化研究	2018RWSK02	基本科研业务费项目	阮俊虎	2018-04	2020-04	9.5
71	众数相关理论及其在收入分配中的应用研究	2452018099	博士科研启动费	田茂茜	2018-08	2020-07	10

2.2 中心获奖及证书

表 2-6 经济管理实验教学中心成员科研获奖

序号	奖励名称	获奖项目名称	完成人	获奖年度	获奖级别	获奖等级
1	陕西省科学技术奖	系统生物学新理论、模型及研究方法	刘天军	2012	省部级	二等奖
2	湖南省科学技术进步奖	我国集体林产权制度改革理论分析与政策实践	李桦	2017	省部级	二等奖
3	陕西省哲学社会科学优秀成果奖（论文类）	气候变化对苹果主产区产量的影响——来自陕西省 6 个苹果生产基地县 210 户果农的数据	刘天军蔡起华朱玉春	2014	省部级	三等奖
4	陕西高等学校科学技术奖	圆通制企业成本管理工作标准研究与应用	孟全省	2018	省部级	三等奖
5	陕西省哲学社会科学优秀成果奖（论文类）	新一轮林权改革背景下南方林区不同商品林经营农户农业生产技术效率实证分析——以福建、江西为例	李桦姚顺波刘璨王博文	2018	省部级	三等奖
6	陕西省哲学社会科学优秀成果奖（论文类）	The Local Residents'Concerns about Environmental Issues in Northwest China(西北地区居民的环境保护意识分析)	Fanus A. Aregay 赵敏娟李晓平夏显力陈海滨	2018	省部级	三等奖
7	陕西省哲学社会科学优秀成果奖（论文类）	农户土地承包经营权抵押贷款的行为响应——基于Poisson Hurdle模型的微观经验考察	李韬罗剑朝	2018	省部级	三等奖
8	陕西高等学校人文社会科学研究优秀成果奖（研究报告）	陕西省农民就近城镇化研究	夏显力马红玉曹可清陈伟	2017	厅局级	一等奖

			张玉民 杨 霖			
9	陕西高等学校人文社会科学研究优秀成果奖（论文类）	农户土地承包经营权抵押贷款的行为响应—基于Poisson Hurdle 模型的微观经验考察	李 韬 罗剑朝	2017	厅局级	二等奖
10	陕西高等学校人文社会科学研究优秀成果奖（论文类）	What to Value and How? Ecological Indicator Choices in Stated Preference Valuation	赵敏娟 Robert J.	2017	厅局级	三等奖
11	陕西高等学校人文社会科学研究优秀成果奖（论文类）	Integration and Typologies of Vulnerability to Climate Change: A Case Study from Australian Wheat Sheep Zones	淮建军	2017	厅局级	三等奖
12	杨凌示范区科学技术奖	2014中国旱区农业技术发展报告	刘天军	2015		二等奖
13	杨凌示范区科学技术奖	中国农业产业投资报告	刘天军	2017		二等奖
14	中国林业经济学会2018年度优秀论文	林地产权安全对农户林业管护行为的影响研究——来自南方集体林区浙江、江西林农的调查	杨 杨 李 桦 薛彩霞	2018		二等奖

陕西省科学技术奖

证 书

为表彰陕西省科学技术奖获得者，
特颁发此证书。

项目名称：系统生物学新理论、模型及研究方法

奖励等级：贰等

获 奖 者：刘天军

二〇一二年九月十九日

证书号：2012-2-009-R6

为表彰湖南省科学技术进步奖获得者，特颁发此证书。

获奖项目：我国集体林产权制度改革理论分析与政策实践

奖励等级：二等奖

获奖者：李桦（第6完成人）

证书号：20164007-J2-214-R06

湖南省
科学技术进步奖

证书

湖南省科学技术进步奖

证 书

为表彰湖南省科学技术进步奖获得者，特颁发此证书。

获奖项目：我国集体林产权制度改革理论分析与政策实践

奖励等级：二等奖

获奖单位：西北农林科技大学
（第4完成单位）

二〇一七年三月十五日

证书号：20164007-J2-214-D04

陕西省哲学社会科学优秀成果奖
证　书

为表彰陕西省第十一次哲学社会科学优秀成果获奖者，特颁发此证书。

成果名称：气候变化对苹果主产区产量的影响——来自陕西省6个苹果生产基地县210户果农的数据

成果类别：论　文

获奖等级：三等奖

获奖者：刘天军、蔡起华、朱玉春

二〇一四年一月

证书号：11-12-11-3-Y188

陕西省哲学社会科学优秀成果奖
证　书

为表彰陕西省第十三次哲学社会科学优秀成果获奖者，特颁发此证书。

成果名称： 新一轮林权改革背景下南方林区不同商品林经营农户农业生产技术效率实证分析——以福建、江西为例

成果类别： 论文

获奖等级： 三等奖

成果作者： 李　桦、姚顺波、刘　璨、曹博文

二〇一八年五月

证书号：15-16-13-3-S070

陕西省哲学社会科学优秀成果奖
证　书

为表彰陕西省第十三次哲学社会科学优秀成果获奖者，特颁发此证书。

成果名称： The Local Residents'Concerns about Environmental Issues in Northwest China(西北地区居民的环境保护意识分析)

成果类别： 论文

获奖等级： 三等奖（青年）

成果作者： 【厄立特里亚】Fanus A. Aregay、赵敏娟、李晓平、夏显力、陈海滨

二〇一八年五月

证书号：15-16-13-3Q-S033

陕西省哲学社会科学优秀成果奖
证 书

为表彰陕西省第十三次哲学社会科学优秀成果获奖者，特颁发此证书。

成果名称： 农户土地承包经营权抵押贷款的行为响应—基于Poisson Hurdle模型的微观经验考察

成果类别： 论文

获奖等级： 三等奖

成果作者： 李 韬、罗剑朝

证书号： 15-16-13-3-S072

二〇一八年五月

陕西高等学校人文社会科学研究优秀成果

获 奖 证 书

成果名称：陕西省农民就近城镇化研究

获奖单位：西北农林科技大学、陕西省人民政府研究室

获 奖 者：夏亚力、马红玉、曹可清、陈伟、张玉民、杨霖

奖项类别：研究报告

获奖等级：一等奖

陕西省教育厅

二〇一七年八月二十八日

证书号：GLX0113

陕西高等学校人文社会科学研究优秀成果

获 奖 证 书

成果名称：农户土地承包经营权抵押贷款的行为响应——基于Poisson Hurdle模型的微观经验考察

获奖单位：西北农林科技大学

获 奖 者：李韬、罗剑朝

奖项类别：论文类

获奖等级：二等奖

陕西省教育厅

二〇一七年八月二十八日

证书号：JJX0033
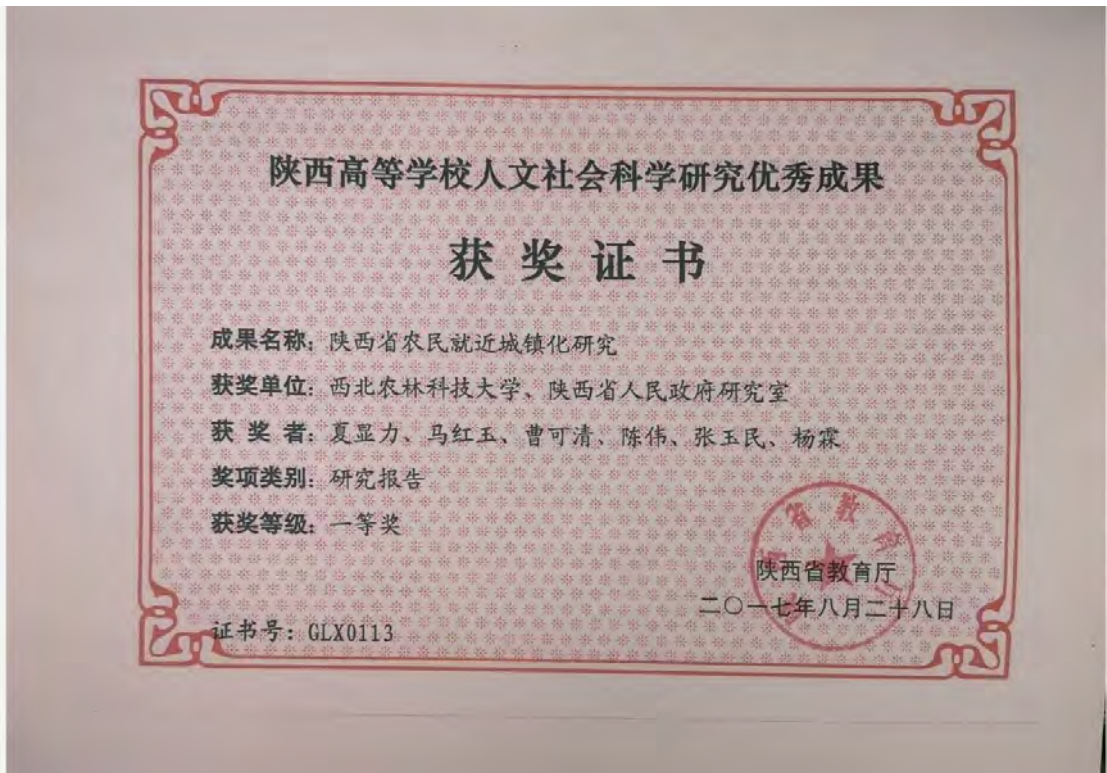
陕西高等学校人文社会科学研究优秀成果

获 奖 证 书

成果名称：What to Value and How? Ecological Indicator Choices in Stated Preference Valuation

获奖单位：西北农林科技大学、Clark University、University of Connecticut

获 奖 者：赵敏娟、Robert J. Johnston、Eric T. Schultz

奖项类别：论文类

获奖等级：三等奖

陕西省教育厅

二〇一七年八月二十八日

证书号：JJX0089

陕西高等学校科学技术奖

获 奖 证 书

项目名称：圆通制企业成本管理工作标准研究与应用

获奖等级：三等奖

获奖单位：西北农林科技大学　圆通科技股份有限公司

西安财经学院

获 奖 者：孟全省　王民权　王新安　刘允飞

白雯丽

陕西省教育厅

二〇一八年三月

杨凌示范区科学技术奖

证 书

为表彰杨凌示范区科学技术奖
获得者，特颁发此证书。

项目名称： 2014中国旱区农业技术发展报告
奖励等级： 二等
获 奖 者： 刘天军

二O一五年五月二十七日

证书号：15-2-02-R2

杨凌示范区科学技术奖

证 书

为表彰杨凌示范区科学技术奖
获得者，特颁发此证书。

项目名称：中国农业产业投资报告

奖励等级：二等

获 奖 者：刘天军

二〇一七年四月十五日

证书号：17-2-03-R1

荣誉证书

杨扬、李桦、薛彩霞：

你们撰写的论文：《林地产权安全对农户林业管护行为的影响研究——来自南方集体林区浙江、江西林农的调查》获中国林业经济学会 2018 年度优秀论文二等奖。

特发此证，以资鼓励。

中国林业经济学会

二〇一八年十二月九日

2.3 出版专著

表 2-7 经济管理实验教学中心成员公开出版专著、编著

序号	著作名称	出版社	出版时间	作者	字数（千字）	类别
1	商业银行资本管理办法学习读本	中国农业大学出版社	2013.01	杨虎锋	420	编著
2	企业成本管理工作标准	中国财政经济出版社	2013.05	孟全省	372	编著
3	小额贷款公司的制度安排及其绩效评价	中国金融出版社	2014.11	杨虎锋	236	专著
4	中国农村信用合作社管理体制改革研究	中国金融出版社	2014.11	杨　峰	220	专著
5	地方政府在加快农村信用体系建设中的作用研究	西北农林科技大学出版社	2015.01	李　韬	208	专著
6	技术接近、地理位置与产业集聚的技术溢出效应研究	中国社科出版社出版	2015.01	张晓宁	201	专著
7	陕西省农户借贷行为研究	中国金融出版社	2015.06	牛　荣	201	专著
8	创新生态与创新国度的理论与时间	社会科学文献出版社	2015.10	唐银山 梁洪松 姚顺波	311	编著
9	中国农村合作医疗制度研究	中国金融出版社	2016.01	张永辉	208	专著
10	中间层参与的上市企业信息披露的博弈分析与实证研究	西北农林科技大学出版社	2016.07	淮建军	233	专著

11	集体林权制度改革对中国木材供给的影响——基于省级面板数据的实证分析与 GFPM 预测	中国林业出版社	2016.08	张　寒	440	专著
12	渭河流域粮食作物虚拟水贸易	社会科学文献出版社	2017.11	赵敏娟	140	专著
13	中国农户创业选择——基于收入质量与信贷约束作用视角	社会科学文献出版社	2017.11	彭艳玲 孔　荣	287	专著
14	基于企业成长视角的组织创新驱动因素及矩阵式战略体系设计	西北农林科技大学出版社	2018.06	梁洪松	185	专著
15	苹果矮化栽培模式技术经济评价研究	科学出版社	2018.09	邵砾群	230	专著
16	情系"三农"，振兴乡村——研究生寒假调研优秀作品汇编	西北农林科技大学出版社	2018.01	赵敏娟 夏显力	215	编著
17	流域生态补偿：基于全价值的视角	社会科学文献出版社	2018.10	樊　辉 赵敏娟	189	专著
18	中国农业产业投资研究	中国财政经济出版社	2018.11	刘天军	220	编著

SYYHZBGLBFSXXXDB

《商业银行资本管理办法（试行）》
学习读本

杨虎锋 主编

中国农业大学出版社

ZHONGGUONONGYEDAXUE CHUBANSHE

PRIVATE COSTS MANAGEMENT
WORKING STANDARD

企业成本管理工作标准

孟全省 王民权 编著

科学工作
快乐工作
享受工作

小额贷款公司的
制度安排及其绩效评价

杨虎锋 ◎ 著

中国金融出版社

中国农村信用合作社
管理体制改革研究

杨　峰◎著

中国金融出版社

责任编辑：张怡姮
责任校对：刘　明
责任印制：陈晓川

地方政府
在加快农村信用体系建设中的作用研究

李韬 著

DIFANG ZHENGFU
ZAI JIAKUAI NONGCUN XINYONG TIXI
JIANSHEZHONG DE ZUOYONG YANJIU

地方政府在加快农村信用体系建设中的作用研究

李韬 著

技术接近、地理位置与产业集聚的技术溢出研究

张晓宁 著

Jishujiejin Diliweizhi Yu Chanyejiju De Jishuyichu Yanjiu

中国社会科学出版社

陕西省农户借贷行为研究

牛 荣 ◎ 著

B 管理蓝皮书

BLUE BOOK OF MANAGEMENT

中国管理发展报告

（2015）

中国管理科学学会学术委员会

南京敏捷企业管理研究所

主编/张晓东

副主编/张卫

ANNUAL REPORT ON MANAGEMENT

IN CHINA (2015)

2015版

创新生态与创新国度的理论与实践

唐银山 梁洪松 姚顺波*

摘要： 创新是管理理论与实践的一个重要组成部分，是企业甚至国家生存和发展的一个重要策略。自从熊彼特在20世纪初将这个理念引入管理领域后，经过近一个世纪的发展和完善，创新已经被绝大多数管理者当成企业发展的基本战略。目前创新还基本上是以企业为主要对象，以单位本身为参照点，主要研究企业单位个体的创新激励和利用机制，但从生态视角考虑创新，并以整体生态系统作为研究目标的文章还比较少见。本文将从个体、单位和社会群体的角度，从创新所代表的不同层面包括本体、所用和价值出发，结合创新所处的整体环境条件来重新思考创新的定义，试图从理论上对创新这一概念进行重新梳理，提出了创新生态系统三要素（人、物、境）的整体动态平衡这一概念。在实践层面，从创新生态角度出发，除了讨论创新所产生的生态机制以外，我们还将着重讨论创新的应对机制，从三要素之间另一个层面，提出三项法则（发明、学习和适应）并进一步进行论证，其中主要讨论国家体制如何适应变革需求，以期国家体制、企业精神和个人努力能够在一个有机的正能量环境当中，实现和达到创新国度这一状态，同时也对国家、企业和个人在创新当中所起的不同作用和责

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* 唐银山，英国雷丁大学亨利商学院副院长，教授；梁洪松，西北农林科技大学经济管理学院副教授；姚顺波，西北农林科技大学经济管理学院教授。

管理蓝皮书
BLUE BOOK OF MANAGEMENT

广视角·全方位·多品种

- 管理蓝皮书系由中国管理科学学会学术委员会和南京敏捷企业管理研究所共同主编，是海内外知名的管理学者、专家以及广大企业管理者集体智慧的结晶。它关注管理科学前沿，关注管理热点和趋势，以我国管理的实践需要为依归，融汇了海内外管理专家的思想精髓，使本书具有较强的学术性、前瞻性和时代感。

- 它紧密围绕国家发展战略布局，立足中国管理实践，关注社会责任，以详实的数据多角度分析了2014~2015年度中国管理的发展状况，精选了一批中国管理实践的优秀案例，使本书具有较高的指导性、特色性和实用性。相信此书的出版能够为促进我国管理科学的发展，促进企业的转型与创新，提升企业的经营管理水平，做出应有贡献。

·权威平台·智库报告·连续发布

中国农村合作医疗制度研究

张永辉 ◎ 著

中国金融出版社

中间层参与的
上市企业信息披露的
博弈分析与实证研究

淮建军 著

中间层参与的上市企业信息披露的博弈分析与实证研究

淮建军 著

集体林权制度改革
对中国木材供给的影响

——基于省级面板数据的实证分析与GFPM预测

JITI LINQUAN ZHIDU GAIGE
DUI ZHONGGUO MUCAI GONGJI DE YINGXIANG

张 寒 著

中国林业出版社

渭河流域粮食作物
虚拟水贸易

基于非市场价值的视角

史恒通　赵敏娟　著

VIRTUAL WATER TRADE OF CROPS
IN THE WEI RIVER BASIN
Based on the View of Non-market Value

ENTREPRENEURIAL

中国农户创业选择

基于收入质量与信贷约束作用视角

彭艳玲　孔　荣　著

FARM HOUSEHOLD'S ENTREPRENEURIAL
CHOICE IN CHINA
Based on the Impacts of Income Quality and Credit Constraints

中国"三农"问题前沿丛书
中国农户创业选择
—— 基于收入质量与信贷约束作用视角

基于企业成长视角的
组织创新驱动因素
及矩阵式战略体系设计

梁洪松　著

基于企业成长视角的组织创新驱动因素及矩阵式战略体系设计

梁洪松　著

本书如有印装质量问题，请与本社联系

苹果矮化栽培模式技术
经济评价研究

邵砾群／著

科学出版社

内 容 简 介

中国苹果产业发展正经历由乔化稀植制度、乔化密植制度向矮化密植集约制度变迁，由以科技含量较低的粗放型经营模式向以科技含量高的资本密集型经营模式过渡过程。本书依据要素禀赋理论与诱致性技术变迁理论，采用规范分析与实证分析相结合的方法，以中国环渤海湾优势区和黄土高原优势区的 15 个苹果示范县、635 个苹果种植户的实地调研数据为基础，在资源与要素禀赋所诱致的苹果栽培技术的变化与相应的制度性投入方面进行分析，研究苹果栽培制度中矮化密植集约栽培模式发展缓慢的根本原因，并设计相应的解决方案。

本书适合于从事区域经济、农业产业经济、农业技术推广等方面研究的科研人员、高校教师、研究生、业界从业人员以及政府或农业技术推广部门的工作人员、政策制定者和有关管理人员等阅读参考。

情系"三农",振兴乡村

——研究生寒假调研优秀作品汇编

赵敏娟　夏显力·主编

西北农林科技大学出版社

情系"三农"，振兴乡村
——研究生寒假调研优秀作品汇编
赵敏娟　夏显力　主 编

流域生态补偿：
基于全价值的视角

WATERSHED ECOLOGICAL
COMPENSATION:
A VIEW BASED ON FULL VALUATION

樊辉　赵敏娟　著

中国"三农"问题前沿丛书

流域生态补偿：基于全价值的视角

2018
中国农业产业
投资报告

杨凌农业高新技术产业示范区管委会
科技部中国农村技术开发中心　　　　著
西北农林科技大学

《2018 中国农业产业投资报告》

编 委 会

2.4 发表论文

表 2-8 经济管理实验教学中心成员科研论文

序号	论文名称	作者姓名	通讯作者	期刊名称及年、卷、期、页码	期刊级别
1	Did the Key Priority Forestry Programs affect income inequality in rural China？	刘天军	刘 璨（外）	Land Use Policy,2014(38):264-275	SSCI
2	Liushou Women's Happiness and its Influencing Factors in Rural China	梁洪松	梁洪松	Social Indicators Research,2014,117(3):907-918	SSCI
3	Actor, Customary Regulation and Case Study of Collective Forest Tenure Reform Intervention in China	骆耀峰	骆耀峰	small-scale forestry,2015,14(2):155-169	SSCI
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121	农民专业合作社纵向一体化的理论逻辑、现实考察与演进路径——基于陕西省52家种植业合作社的调研	张学会（学）	王礼力	农村经济,2014(02):103-108	B
122	企业碳业务的会计核算与信息披露	张 丹（学）	杨文杰	会计之友,2014(05):28-30	B
123	上市公司股票股利政策的影响因素分析	聂金玲（学）	雷玲	会计之友,2014(18):21-25	B
124	上市公司股权激励实施效果研究	杨娇娇（学）	李小健	财会通讯,2014(21):54-56	B
125	沈阳市城市土地利用效率品评价及影响因素分析	王丽娜（学）	李世平	水土保持研究,2014,21(05):311-3	B

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126	审计委员会特征与会计稳健性-来自制造业上市公司的经验数据	邹润玲（学）	杨文杰	财会通讯,2014(24):20-22	B
127	退耕还林对志丹县农业生产效率的影响	曹彤 郭亚军	郭亚军	林业经济,2014,36(05):47-51+111	B
128	西北荒漠化地区土地生态安全评价研究-以酒泉市为例	刘凌冰（学）	李世平	水土保持研究,2014,21(04):190-194	B
129	应用三阶段DEA模型分析退耕还林农户商品林的技术效率	李博（学）	李桦	西北林学院学报,2014,29(06):276-281	B
130	中国木本食用油料价格波动规律分析	李婷（学）	郭亚军	林业经济问题,2014,34(02):138-144	B
131	中小企业融资能力影响因素研究-基于中小板上市公司数据	陈战运（学）	杨文杰	财会通讯,2014(15):76-78	B
132	中小企业债务融资影响因素分析	陈战运（学）	杨文杰	会计之友,2014(16):38-41	B
133	资本结构对企业价值影响的实证研究—以房地产上市公司为例	于少磊（学）	李小健	会计之友,2014(15):78-82	B
134	"净额法"处理碳排放权会计实务思考	李阳（学）	杨文杰	财会月刊,2015(16):58-60	B
135	"新常态"下国家农业示范区产业结构优化研究	朱宝（学）	刘天军	农村经济,2015(06):44-47	B
136	城郊农户对无公害蔬菜的认知及生产行为分析	徐家鹏	徐家鹏	北方园艺,2015(22):202-206	B
137	城市土地利用变化对生态系统服务的影响—以西安市为例	钟媛（学）	赵敏娟	水土保持研究,2015,22(01):274-280	B
138	城镇化、空间溢出与省域城乡收入差距——基于空间杜宾模型偏微分方法及中国的实证	徐家鹏	徐家鹏	农村经济,2015(11):41-49	B

139	大唐袜业和义乌袜业的集群品牌模式比较	李大垒	李大垒	企业管理,2015(02):66-69	B
140	东北沟小流域生态服务价值评估	高 洋（学）	宋健峰	中国水土保持,2015,35(02):62-66	B
141	宏观经济动态性视角下的环境政策选择 - 基于新凯恩斯DSGE模型的分析	徐文成（学）	薛建宏	中国人口·资源与环境,2015,25(04):101-109	B
142	后林权改革视角下林地经营模式选择影响因素分析	戴君华（学）	李 桦	林业经济,2015,37(07):50-55	B
143	基于CORPS模式的农林院校科研绩效评价-以西北农林科技大学为例	雷 蕾（学）	孟全省	财会通讯,2015(16):72-74	B
144	基于动态引力模型的中国苹果汁出口影响因素研究	岳 璐（学）	王秀娟	北方园艺,2015(17):201-205	B
145	煤炭城市的城镇化与生态环境协调发展量化分析	赵倩楠（学）	李世平	干旱区资源与环境,2015,29(09):45-50	B
146	农民农药使用防护行为及其健康影响分析	王永强	王永强	北方园艺,2015(6):194-196	B
147	农民专业合作社生命周期演化机理及实证研究	张 颖（学）	王礼力	农村经济,2015(03):120-125	B
148	农业上市公司资本结构影响因素分析	樊 迪（学）	李小健	财会通讯,2015(2):41-43	B
149	农业碳排放库兹涅茨曲线实证研究	古南正皓（学）	李世平	统计与决策,2015(10):95-98	B
150	气候变化对苹果主产区单产及单产增长的贡献研究	白秀广	白秀广	中国农业大学学报(自然科学版),2015,20(04):82-91	B
151	社会网络视角下知识管理与农业企业绩效关系研究	李立群（学）	王礼力	科技管理研究,2015,35(13):141-145	B
152	社会资本对桃农生产技术效率的影响及对策研究	徐家鹏	徐家鹏	林业经济问题,2015,35(06):528-533	B
153	天气指数衍生品及其定价研究	孙保敬	李世平	统计与决	B

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154	外部监督、内部压力与环境信息披露相关性实证研究——基于沪市重污染行业上市公司的数据	聂金玲（学）	雷　玲	财会通讯,2015(7):26-30	B
155	新型城镇化视角下的区域生态效率研究	蔡　洁（学）	李世平	资源科学,2015,37(11):2271-2278	B
156	员工绩效管理满意度研究	王建军（学）	张雅丽	财会月刊,2015(11):54-57	B
157	创新，也是一种改变	张晓宁	张晓宁	企业管理,2016(10):1	B
158	河北省耕地利用效率空间差异及影响因素	张　浩（学）	李世平	水土保持研究,2016,23(03):185-191	B
159	基于收入异质性视角的西部农户林地经营技术效率研究——四川省雅安市农户调查	薛彩霞	薛彩霞	林业经济,2015,37(12):36-42+77	B
160	基于营养学视角的中国果蔬产业发展优化研究	朱　宝（学）	刘天军	北方园艺,2016,(7):175-180	B
161	集体林权配套改革非农就业地理距离与农户林业投入行为——基于9省18县面板数据的验证	徐婷婷（学）	李　桦	林业经济问题,2016,36(05):400-405	B
162	气候变化对中国苹果主产区生产布局变迁的影响分析	白秀广	白秀广	北方园艺,2016(1):204-209	B
163	西部地区农户经营非木质产品对收入影响分析	李鹏丹（学）	张雅丽	林业经济,2016,38(11):92-96	B
164	"一带一路"倡议背景下的中波苹果贸易及其对中国苹果产业发展和市场的影响	闫贝贝（学）	刘天军	北方园艺,2017(20):200-205	B
165	低效苹果园改造技术模式、效果及区域差异分析——基于国家苹果产业技术体系24个综合试验站数据的统计分析	闫振宇	刘天军	果树学报,2017,34(01):84-93	B
166	基于NDVI的黄土高原丘陵沟壑区植被覆盖变化及其驱动力	张雅丽	张雅丽	林业经济,2016,38(12):21-25	B

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167	家庭劳动力配置对西部农户非木质林产品经营效率的影响——基于成本效率与利润效率的影响	薛彩霞	姚顺波	林业经济问题,2017,37(05):65-72+108	B
168	人口相关因素对碳排放的影响研究——基于变截距模型的实证分析	王雅楠	孙养学	生态经济,2017,33(12):19-23	B
169	退耕还林生态补偿机制的激励有效性——基于异质性农户视角	张 兴	赵敏娟	林业经济问题,2017,37(01):31-36+102	B
170	半干旱地区农户采用节水灌溉技术的影响因素及收入效应研究--以陕西榆林为例	蒋 伟（学）	陈晓楠	中国农村水利水电,2018(03):66-71	B
171	高管股权激励对农业上市公司绩效的影响研究--基于两类代理成本的中介效应	张倩倩（学）	李小健	财会通讯,2018(29):20-23	B
172	黄土高原苹果农户气候风险的感知脆弱性评估	常 成（学）	淮建军	北方园艺,2018(05):200-205	B
173	基于SERVQUAL的农民专业合作社服务质量评价	范倩文（学）	王礼力	水土保持研究,2018,25(04):344-348	B
174	基于农户视角的生态补偿政策绩效评价	田 爽（学）	孟全省	北方园艺,2018(14):191-196	B
175	利用Google Earth和SRTMGL1进行高分辨率遥感影像正射校正	徐 鑫（学）	张道军	测绘通报,2018(08):62-67	B
176	林业科技服务对农户经营林下经济行为的影响研究	丁秀玲（学）	薛彩霞	林业经济问题,2018,38(05):52-58	B
177	农业上市公司成本粘性特征实证分析	郭嫚嫚（学）	李小健	财会通讯,2018(14):32-36	B
178	陕北和关中苹果主产区气候变化背景下农户生计脆弱性分析	肖 芳（学）	淮建军	北方园艺,2018(16):200-206	B
179	陕西省土地利用碳排放影响因素及脱钩效应分析	李玉玲（学）	李世平	水土保持研究,2018,25(01):382-390	B

180	社会规范对农户节水灌溉技术采用行为的影响分析	陈欣如（学）	王礼力	节水灌溉,2018(08):85-89	B
181	社会资本对农户参与农民用水协会意愿的影响研究	王　静（学）	王礼力	农业现代化研究,2018,39(02):309-315	B
182	资源禀赋、经营方式与农户林地流入行为	韩利丹	李　桦	林业经济问题,2018,38(01):7-14+100	B
183	An Empirical Study on the Impact of Corporate Social Responsibility Information Disclosure on Equity Capital Cost	孟全省	孟全省	学术界,2015(11):257-262	C
184	产权认知、家庭特征与农户土地承包权退出意愿	高　佳（学）	李世平	西北农林科技大学学报(社会科学版),2015,15(05):71-78	C
185	国际原油价格变动对我国农产品价格波动的影响	任　劼（学）	孔　荣	西北农林科技大学学报(社会科学版),2015,15(01):107-113	C
186	基于选择试验模型的生态系统服务支付意愿差异及全价值评估：以渭河流域为例	史恒通（学）	赵敏娟	资源科学,2015,37(02):351-359	C
187	经济增长、环境治理与环境质量改善－基于动态面板数据模型的实证分析	徐文成（学）	薛建宏	华东经济管理,2015,29(02):35-40	C
188	社会网络分析（SNA）在自然资源管理中的应用	骆耀峰	骆耀峰	软科学,2015,29(06):135-138	C
189	社会资本对西部贫困地区农村老年人健康质量的影响路径—基于联立方程模型的中介效应检验	黄伟伟（学）	赵敏娟	人口与经济,2015(05):61-71	C
190	生态系统服务支付意愿及其影响因素分析—以陕西省渭河流域为例	史恒通（学）	赵敏娟	软科学,2015,29(06):115-120	C

191	新丝绸之路经济带研究综述	淮建军	淮建军	学术界,2015(01):219-228+327-328	C
192	杨凌现代农业示范园综合效益评价	雷 玲	雷 玲	西北农林科技大学学报(社会科学版),2015,15(02):76-82	C
193	中国城市经济发展水平比较研究——基于环境友好视角	张宏雷（外）	阮俊虎	财经理论与实践,2015,36(05):108-113	C
194	中国需要怎样的社会创业	薛建宏	汪红梅	财经科学,2015(2):72-79	C
195	资源型城市接续产业的模式选择研究	李大垒	李大垒	江西财经大学学报,2015(03):13-19	C
196	不同收入层次下的农户借贷需求意愿	牛 荣	牛 荣	华南农业大学学报(社会科学版),2016,15(03):38-46	C
197	承载力视角下土地资源可持续发展评价	李 昊（学）	李世平	西北农林科技大学学报(社会科学版),2016,16(04):62-68	C
198	黑河流域生态系统服务需求收入弹性分析	李晓平（学）	赵敏娟	生态经济,2016,32(11):147-151	C
199	基于验证性因子分析的农户收入质量研究	任 劼（学）	孔 荣	重庆大学学报(社会科学版),2016,22(04):54-61	C
200	节水灌溉技术社会生态效益评估——以石羊河下游民勤县为例	徐 涛（学）	赵敏娟	资源科学,2016,38(10):1925-1934	C
201	金融产业集聚发展的空间交互影响研究	李大垒	李大垒	西南民族大学学报(人文社科版),2016,37(10):112-116	C
202	经济理性还是生态理性?农户	姚柳杨	赵敏娟	南京农业大学学报	C

	耕地保护的行为逻辑研究	（学）		(社会科学版),2016,16(05):86-95	
203	贸易开放对中国水环境污染影响的实证研究	史恒通（学）	赵敏娟	重庆大学学报(社会科学版),2016,22(03):64-71	C
204	农村公共投资影响城乡收入差距研究——基于农村内生发展视角的实证分析	徐志文（学）	王礼力	农村经济,2016(01):63-68	C
205	农户土地承包权退出意愿的影响因素	高 佳（学）	李世平	干旱区资源与环境,2016,30(08):23-29	C
206	偏好与消费能力对居民消费行为的影响研究	徐文成（学）	薛建宏	中央财经大学学报,2016(06):97-103	C
207	生态系统服务功能偏好异质性研究——基于渭河流域水资源支付意愿的分析	史恒通（学）	赵敏娟	干旱区资源与环境,2016,30(08):36-40	C
208	蔬菜价格悖论的理论解析	淮建军	淮建军	华中农业大学学报(社会科学版),2016(03):24-30+133	C
209	我国食品体系变化过程中的食品安全问题	张文静（学）	薛建宏	大连理工大学学报(社会科学版),2016,37(04):118-124	C
210	西北生态脆弱区居民生态补偿意愿研究	樊 辉（学）	赵敏娟	西北农林科技大学学报(社会科学版),2016,16(03):111-117	C
211	选择实验法视角的生态补偿意愿差异研究	樊 辉（学）	赵敏娟	干旱区资源与环境,2016,30(10):65-69	C
212	中国农产品价格波动分析:价格粘性的视角	淮建军	淮建军	农村经济,2016(03):55-60	C
213	中国农业能源消耗与CO_2排放:趋势及减排路径——基于Holt-Winter无季节性模型和"十三五"的预测	徐家鹏	徐家鹏	生态经济,2016,32(02):122-126	C

214	中国土地生态安全研究进展与展望	李 昊（学）	李世平	干旱区资源与环境,2016,30(09):50-56	C
215	中转点变化的应急医疗物资联合运送干扰管理研究	阮俊虎	阮俊虎	运筹与管理,2016,25(04):114-124	C
216	PPP模式下环保类公司参与流域治理意愿的影响因素分析	房引宁（学）	赵敏娟	证券市场导报,2017(04):61-66	C
217	保护性耕作技术、种植制度与土地生产率——来自黄土高原农户的证据	李 卫	薛彩霞	资源科学,2017,39(07)1259-1271	C
218	城市化进程对城乡居民收入差距的影响	徐家鹏	孙养学	城市问题,2017(01):95-103	C
219	城乡居民休耕方案支付意愿差异性研究	张 晨（学）	赵敏娟	西北农林科技大学学报(社会科学版),2017,17(05):90-97	C
220	黄土高原区苹果化肥利用效率及影响因素	张 波（学）	白秀广	干旱区资源与环境,2017,31(11):55-61	C
221	集中连片特困区农地转出户生计策略选择研究	蔡 洁（学）	马红玉	资源科学,2017,39(11):2083-2093	C
222	粮食种植户生产环节外包选择行为分析	段 培（学）	王礼力	西北农林科技大学学报(社会科学版),2017,17(05):65-72	C
223	流域治理的PPP政策满意度及其影响因素分析	房引宁（学）	赵敏娟	当代经济科学,2017,39(03):102-107+127-128	C
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Liushou Women's Happiness and its Influencing Factors in Rural China

Hongsong Liang · Yinshan Tang · Xuexi Huo

Abstract The economic development of urban cities in China has attracted a large number of labour from the rural countryside. The married migrant workers will usually leave their wives' homes to look after the other family members and the farmland. A special term *liushou* women, has been created for this group of women. Among the 87 million rural residents, 47 million of them are *liushou* women according to the recent survey conducted by China Agricultural University. They play a crucial role in the development of rural economy and an essential role to the social stability of rural China. In this research, the factors that influence the happiness of *liushou* women were investigated in the Western part of China. Based on the population investigated, it was found that the financial situation, personality, government efficiency, conjugal relationship and relationship with in-laws are the significant factors influencing the happiness of *liushou* women. This finding demonstrates that the Chinese women are willing to sacrifice their personal interest for the interests of their families.

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1 Research Background

Since 1980s', along with the rapid development of urbanization, industrialization and modernization, a large number of married young men in the rural countryside had moved to cities to make their living, coupled with the *hukou* (strict residence management) system, their spouses had to be left behind to look after their parents or children, which created the *liushou* phenomenon. In this setup, rural young men work in the cities and *liushou* wives take over farming and domestic duties at home. It has replaced the traditional duty allocations for men and women, which is regarded as "men working, women farming". This can be regarded as an extension to the traditional duty allocations for man and woman, i.e. "domestic wife and social husband". Most importantly, this *liushou* phenomenon originated from the rural farmers as "one family-two jobs"; one of the effective arrangements to escape poverty (Zuo and Song 2002). This has created more pressure on *liushou* women by taking over almost all the domestic work which used to be shared between them and their husbands. Due to the sharp increase of *liushou* population together with the importance of agriculture and social stability in the rural area, more attention has been attracted to the research of the welfare of this population in recent years in China.

Starting from 2000, the number of *liushou* women has increased sharply and it still increases each year. In 2000, the total number reached 13 million; by 2004, it increased to 43.1 million and in 2005, it went over 47 million. The current estimate stands for over 50 million (Yu 2011). *Liushou* women make important contributions to the welfare of their family, the rural development, the agriculture production, city construction and in return they have to make sacrifices towards their own needs. Such a situation is not usually fully recognized, including the women themselves. The duties they carry out in farming, the need for personal development and the need for mental comfort have given them a great deal of pressure, which may cause confusion and contradiction (Xu 2009). Various attempts have been made to address the issue by the government and different organizations tying to offer their help. However, a full understanding of the needs for such group is needed, which can enable the government to prioritize the offers to maximize the impact.

Most of the research focused on the following areas: (1) The causes for such a special group. Wang (2007) used gender division from institutional and traditional aspects to explain the formation of *liushou* women; Kang (2008) paid more attention to the physical capabilities of women; (2) Use case studies to examine the challenges and difficulties that *liushou* women are facing and propose solutions to helping them (Shi 2007); (3) Study the contributions that *liushou* women made towards the development of rural areas (Ye 2009); (4) Studies on specific questions, such as children's education, social support network, personal development and rights-safeguarding (Xu 2007).

Scholars from the West selected measurable indicators to investigate the factors which affect the happiness of individual (groups) of women. In summary, factors affecting women's happiness can be grouped as following: Economic (GDP, personal income), personal characteristics (age, gender, religion, race, personality), social situation (education, health, type of work, unemployment), social relations (marriage and intimate relationships, children, family and friends) and broader socio-economic and political environment (income inequality, inflation, welfare system and public security, democratic, climate and natural environment, community safety, level of urbanization). Stevenson and Wolfers (2009) reported that women's happiness is related to marriage, healthy, economic status and job. Similarly among the white women in America, their happiness is related to age, job satisfaction, marriage, children, education, economic status and health. The report

of "How Dutch women got to be the happiest in the world" stated that liberty is the most important factor to make them happy (Ward 2011). Liberty includes the choices of personal lifestyle and the socio-economic standing. Job satisfaction is believed to be the most important factor towards life satisfaction (Booth and Van 2008). In contrast, life satisfaction is related to be happy through pleasure, through engagement, and through meaningful activities (Peterson et al. 2005). When groups of women were investigated in the UK and Germany, a reduced working hour can actively promote their happiness (Gash 2010). National wealth has a close association with subjective well-being, whereas the subjective well-being is related only to personal income in developing countries, but not in the developed countries (Diener and Biswas-Diener 2002). Other studies suggested that marriage can bring more happiness than cohabitation (Stack and Eshleman 1998). Four leisure activities, such as sport/exercise, music, church and watching TV soaps are linked with happiness (Hills and Argyle 1998). In Pakistan, on the other hand, autonomy brings happiness and satisfaction to women (Ali and Haq 2006). In the USA, self-esteem, satisfaction with life and self-objectification are more important for the college women (Mercurio and Landry 2008). Self-esteem and job satisfaction were found with more intense influence on female than male's happiness (Pugliesi 1995). Sexual orientation and behaviour were also found important towards the happiness of 16,000 American adults (Blanchflower 2004).

As discussed above, we can see that most of the studies focused on internal and economic factors contributing to the happiness of women. External factors such as social and family related aspects were not covered. Researches on all the factors affecting the happiness of *liushou* women are scarce as most of the studies being interested in finding the marital challenges they face. The most extensive study was carried out by Xu (2010) who investigated a number of influential factors which affect the stability of marriage in the West part of China. In this research we introduced a number of external factors including social and community related factors to identify their role towards the happiness of *liushou* women.

2 Data and Research Methods

2.1 Data Collection

The research data was collected from surveys conducted on *liushou* women in Yangling district of Shaanxi province from April to November, 2011. The survey was conducted among the local residence of *liushou* women between the ages of 18–60. The selection criteria for *liushou* women was: married with their husbands working in a different county, with a minimum separation of longer than 6 months per year.

This survey was conducted by sampling individuals randomly from 4 villages of 2 towns. Data was collected based on interviews with each selected *liushou* women by investigators. The total of 83 women was interviewed with 81 of them provided complete sets of data.

The demography of sampled population shows that the majority of *liushou* women are in the age range of 41–50. The other age group from 31 to 40 is the second highest population. The combination of these two groups forms 74 % of the total. These age groups have the responsibilities of looking after the elderly as well as their children, which has the highest extra burdens and responsibilities. The education attainment among the *liushou* women is generally low with most of them below junior middle school level of education, which might be one of the limitations for them to looking for jobs in the cities.

2.2 Variable Measurement

The dependent variable is *liushou* women's happiness levels—which has been expressed by the interviewee themselves. It is a subjective indicator, however, can be easily quantifiable after simple explanations. Variables collected are in the following 6 categories: (1) Personal details such as age, education attainment, and occupation (farming and non-farming). (2) Economic situation includes whether they regard themselves as well off or not, living condition, and health care conditions. (3) Social relations include relationship with in-laws, children, neighbours and husband. (4) Local government related factors include government policies, government efficiency. (5) Physical and psychological status includes whether the work is easy, health status, loneliness and optimistic personality. (6) Financial burdens include the number of dependent children and elderly people. Among categories 2, 3, 4, 5, we designed 13 questions to be answered using Likert scale, whereas a 1 is assigned to "Strongly disagree", a 2 for "Disagree", a 3 for "Neutral", a 4 for "Agree" and a 5 for "Strongly agreed". For education attainment, the "primary school and below" with a 1 assigned, "junior middle school" with 2, "high school (vocational school)" with 3, "junior college" with 4 and "bachelors degree and above" with 5. For occupation, "farming" assigned with a 0 and "non-farming" with 1 with the maximum total score of 100. The scores below and equal 39 is regarded as unhappy, 40–59 for basic happiness, 60–79 for happy and 80–100 for very happy.

2.3 Research Method

All sampled data were tested as a normal distribution. Eviews was firstly used for univariate analysis, i.e. through cross-over analysis between five independent and dependent variables respectively to identify any possible relationships and then the *t* test was used to check the significance of such relationships. Based on the cross-over analysis, multivariate analysis was then applied coupled with regression models to identify the influencing factors of *liushou* women's happiness.

3 Results of Data Analysis

3.1 Univariate Analysis

In the 81 valid respondents, 33.3 % were in the category of very happy, 35.8 % were happy, 24.7 % were basically happy, and 6.2 % were unhappy. The results show that over than 93 % of the women interviewed consider themselves as basically happy or better Fig. 1 and Table 1.

3.1.1 The Cross-analysis Between Personal Details and Liushou Women's Happiness

Table 2 shows that age, education attainment and occupation have no obvious link with *liushou* women's happiness. The age groups from 30 to 50, which contribute to most of the investigated population, have the highest burden on their shoulder. However, the burden does not seem to be the factors to cause their unhappiness.
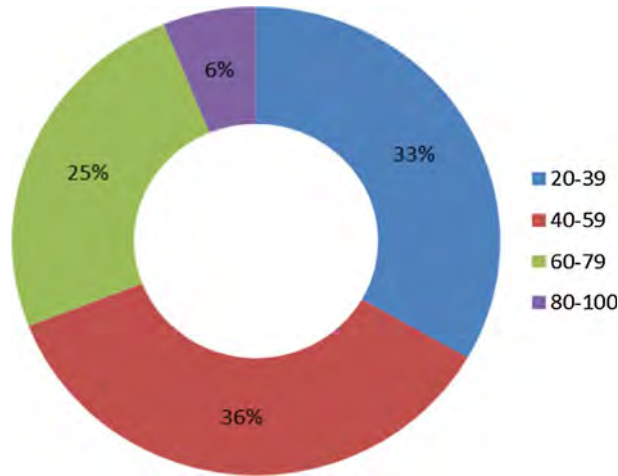
Fig. 1 Distribution of *liushou* Women's happiness

Table 1 The demography of sample population

	Categories	%	Sample size
Age	18–30	14.8	12
	31–40	27.2	22
	41–50	46.9	38
	51–60	11.1	9
Education attainment	Primary school and below	33.3	27
	Junior middle school	53.1	43
	High school, vocational school	9.9	8
	Junior college	2.5	2
	Bachelor degree and above	1.2	1
Occupation	Farming	95.1	77
	Non-farming	4.9	4

3.1.2 The Cross-analysis Between Economic Positions and Liushou Women's Happiness

Table 3 shows that the relationship between happiness and "sufficient household savings" is highly significant ($P < 0.01$), which shows a strong link whereas "housing conditions" and "medical conditions" do not have significant impact. This indicates that to have sufficient cash in their savings does provide the enough weight to make the women feel happy over other conditions.

3.1.3 The Cross-analysis Between Social Relations and Liushou Women's Happiness

Table 4 lists the test results between the happiness and social relationships including their relationships within the family members and neighbours. Good relationship with children, spouse and parent in-laws are all significantly different ($P < 0.05$), which indicates that these

Table 2 The cross-analysis between *liushou* women's happiness and age, educational attainment and occupation (N = 81)

Variable	t	P
Age	−0.93774	0.3512
Educational attainment	0.513221	0.6092
Occupation	−0.98595	0.3272

three variables have links with the women's happiness. Good neighbourhoods on the other hand plays a less significant role towards the happiness of *liushou* women. It seems evident that the Chinese women, especially the *liushou* women, will feel happy as long as their family members are happy with them. Towards better economic condition, i.e. to have sufficient household saving in their bank account, they are ready to sacrifice their personal needs and take over almost all the responsibilities of the household apart from earning money.

3.1.4 The Cross-analysis Between Local Government Related Factors and Liushou Women's Happiness

Table 5 shows the results after comparing the connections between happiness and local official related factors. Both two variables included in the study were found significant with government efficiency highly significant ($P < 0.01$) and government policies significant ($P < 0.05$). From the interviews carried out, it was clear that *liushou* women find it more pressurized to deal with the local officials than deal with family related issues. The activities are not easy; including preparing application documents to claim benefits and visiting high ranking governmental departments to argue for the benefits they ought to receive.

3.1.5 The Cross-analysis Between Individual Physical And Psychological Factors and Liushou Women's Happiness

Table 6 shows that to be optimistic and having physically manageable jobs are both important factors ($P < 0.01$). Intensive physical labour and manual work does have some negative affect towards the happiness of the women interviewed, however, optimistic is highly influential ($P < 0.001$).

3.1.6 The Cross-analysis Between Financial Burdens and Liushou Women's Happiness

The number of children and elderly they look after did not show significant influence to the happiness of *liushou* women (Table 7).

Table 3 The cross-analysis between *liushou* women's happiness and economic positions (N = 81)

Variable	Agree degree					t	P
	1	2	3	4	5		
Economic positions							
Good housing conditions	4.9	12.3	37	42	3.7	1.609671	0.1115
Good medical conditions	1.2	12.3	38.3	40.7	7.4	1.849358	0.0681
Sufficient household savings	16	27.2	33.3	22.2	1.2	4.999725	0.0002**

** $P \leq 0.01$

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Table 4 The cross-analysis between *liushou* women's happiness and social relationships (N = 81)

Variable	Agree degree					t	P
	1	2	3	4	5		
Social relationships							
Good relationship with in-laws	1.2	11.1	53.1	25.9	8.6	2.066072	0.0421*
Good relationship with children	–	–	9.9	56.8	33.3	2.453085	0.0164*
Good neighbourhood	2.5	2.5	19.8	61.7	13.6	−0.34211	0.7332
Good conjugal relationship	0	9.9	12.3	56.8	21	2.359622	0.0208*

*$P \leq 0.05$

Table 5 The cross-analysis between *liushou* women's happiness and government related factors (N = 81)

Variable	Agree degree					t	P
	1	2	3	4	5		
Governmental factors							
High government efficiency	22.2	34.6	27.2	14.8	1.2	4.432598	0.0002**
Good government policy	18.5	34.6	25.9	16	4.9	3.09705	0.0027**

**$P \leq 0.01$

3.2 Multivariate Analysis

Based on the results from cross-over analysis, a multivariable linear regression model was used to analyze the influential factors for happiness using Eviews. Results are shown in Table 8.

From the multivariable linear regression model established above, the optimal stepwise regression equation method was then applied to remove the undependable variables with Eviews. Variables $x_1, x_2, x_3, x_{15}, x_9, x_8, x_5, x_{12}, x_{16}$ were gradually removed. The remaining $x_4, x_6, x_7, x_{10}, x_{11}, x_{13}, x_{14}, x_{17}, x_{18}$ were then re-ranked based on the t-test result as $x_{14}, x_6, x_{18}, x_{17}, x_{11}, x_{13}, x_8, x_{10}, x_7$. To eliminate the possible multi-collineary effect, stepwise regression method was applied to the new ranking and then to be introduced into the new multivariable linear regression model one by one to carry out stepwise regression again. The final results are shown in Table 9.

Household savings, optimism, government efficiency, conjugal relationship and the relationship with in-laws are the most important factors contribute to the happiness of *liushou* women.

Table 6 The cross-analysis between *liushou* women's happiness and individual physical and psychological factors (N = 81)

Variable	Agree degree					t	P
	1	2	3	4	5		
Individual psychological factors							
Optimism	3.7	14.8	34.6	28.4	18.5	5.135635	0.0001**
Light physical work	6.2	33.3	37	16	7.4	2.688363	0.0088**

**$P \leq 0.01$

Table 7 The cross-analysis between *liushou* women's happiness and financial burdens (N = 81)

Variable	Number of people					t	P
	1	2	3	4	5		
Financial burdens							
Number of child	1.2	22.2	56.8	19.8	–	0.439506	0.6615
Number of elderly	30.9	17.3	40.7	3.7	7.4	0.941428	0.3494

Table 8 Multivariate linear regression model with Eviews (N = 81)

Variable	Coefficient	Std. Error	t	P
Age (x_1)	−0.18394	0.298533	−0.61614	0.5401
Education attainment (x_2)	−2.34773	2.710114	−0.86628	0.3897
Occupation (x_3)	−6.8535	8.262126	−0.82951	0.41
Number of children (x_4)	1.538344	3.21141	0.479025	0.6336
Number of elderly (x_5)	0.517896	1.802985	0.287244	0.7749
Household savings (x_6)	4.393467	2.486983	1.766585	0.0822
Relationship with in-law parents (x_7)	0.725134	2.337029	0.31028	0.7574
Relationship with children (x_8)	4.457664	3.64193	1.223984	0.2256
Neighbourhood (x_9)	−2.89832	2.466808	−1.17493	0.2445
Conjugal relationship (x_{10})	2.893631	2.508481	1.153539	0.2531
Light physical job (x_{11})	2.634771	1.938146	1.359428	0.1789
Health condition (x_{12})	−1.48674	2.278452	−0.65252	0.5165
Loneliness (x_{13})	0.556938	1.988645	0.280059	0.7804
Optimism (x_{14})	4.564947	2.297774	1.986683	0.0514
Housing conditions (x_{15})	−0.47604	2.218772	−0.21455	0.8308
Medical conditions (x_{16})	0.383623	2.915307	0.131589	0.8957
Government policy (x_{17})	−0.16317	2.177094	−0.07495	0.9405
Government efficiency (x_{18})	4.880976	2.414099	2.021863	0.0475[*]
C	66.1073	12.73661	5.190337	0[**]
R-squared	0.499437	F-statistic		3.436703
Adjusted R-squared	0.354113	Prob (F-statistic)		0.000151

*$P \leq 0.05$, **$P \leq 0.01$

4 Discussion and Analysis

Liushou women form a unique population in China under the current social and economic development stage. The population size of such group as well as the contribution to the society from this single group has such an importance that may shape the social landscape of rural China. When compared with the happiness of women in the literature, the formation and social impacts of such group in China are not the same. There are factors found in common affecting the happiness between the Chinese *liushou* women and the women in the developed countries, such as optimism, good attitude towards life and good marital relationships. However, there are specific factors apply to the *liushou* women only; more happiness and satisfaction could be drawn from good relationships with their in-laws. It seems that *liushou* women consider the happiness of the whole family as their main source

Table 9 The influencing factors of *Liushou* women's happiness in multivariate linear regression model with Eviews (N = 81)

Variable	Coefficient	Std. Error	t	*P*
Household savings(x_6)	5.14404	1.89479	2.714833	0.0082**
Optimism (x_{14})	4.469779	1.797395	2.486809	0.0151*
Government efficiency (x_{18})	4.136942	1.788547	2.313018	0.0235*
Conjugal relationship (x_{10})	4.257784	2.087895	2.039271	0.0449*
Relationship with in-laws (x_7)	1.319624	2.086269	0.632528	0.0452*
C	64.71223	2.871117	22.53904	0
R-squared	0.926618	F-statistic		110.16058
Adjusted R-squared	0.988393	Prob (F-statistic)		0

$*P \leq 0.05$, $**P \leq 0.01$

of happiness rather than their own needs. Indictors from the literature covered the whole spectrum of objective and subjective measures. They almost all focused on personal interests of women. Leisure activities such as sport/exercise, music, visiting Church and watching TV Soaps (Hills and Argyle 1998), engaging with pleasure and meaningful activities (Peterson et al. 2005), becoming married than cohabitation (Stack and Eshleman 1998), normal sexual orientation and behaviour (Blanchflower 2004) and marital status and children (Stevenson and Wolfers 2009). External factors were not fully covered. Under the rural Chinese context, however, external factors, especially family factors play a significant role towards the happiness of *liushou* women.

It was found that national wealth is linked with subjective happiness and personal income and happiness correlation appears to be larger in poorer nations (Diener and Diener 2002). Results from this study support this conclusion. As China, especially in rural areas, is still in the economic development stage, the satisfaction obtained from having sufficient amount of income each household might be significantly higher than the developed countries. From poor to having the certainty of a good living, the satisfaction is evident. Although financial income is not comparable with Western standards, most of the *liushou* women thought their "family's economic position was good". The comparison was obviously made with the non-*liushou* families in the neighbourhoods. This satisfaction may also be affected by the Chinese culture. In the long process of feudal society, the Chinese have developed a family centric culture. The interest of the whole family supersedes the interest of each individual member of the family.

Government efficiency is an interesting indicator for the Chinese *liushou* women. It is interesting to see the efficiency of governing body has such an impact on the happiness of *liushou* women. After a close look at the findings, it is not the effective responses from the government officials will create happiness; it is rather the inefficiency has caused the unhappiness to this group of women. Among the people surveyed, 56.8 % of them were not happy with their local government's efficiency, which has caused certain degree of unhappiness. Low degree of education, lengthy process of application when applying for social benefits, bureaucratic system might be the external factors that may cause the *liushou* women to be unhappy, however, a lower degree of confidence in dealing with chores rooted from the cultural and educational experiences from their childhood might be the internal factors.

Age is regarded as one of the important factors that affect the happiness of women. It has been found at the age of 28, they would have full confidence in their love life and felt the happiest. The happiness will decline after reaching 40 and then gradually became less

happy (Stevenson and Wolfers 2009). In our study, we covered 4 age groups from 18 to 60. Age was not found related with their happiness among the Chinese *liushou* women. This result supports our earlier claim that *liushou* women's happiness is built upon the happiness of the family. It seems that crossing all age groups, how to take good care of their families was still the predominant task in their lives.

Self-esteem and job satisfaction (Pugliesi 1995), part-time (Booth and Van 2008) and reducing working hours (Gash 2010) were all found contributing positively to the happiness of women. Similarly, we have found most of the women surveyed preferred less physical labour work in the farm.

Liberty or self-autonomy is the most important factors that make women feel happy (Ali and Haq 2006, Inglehart et al. 2008, Mercurio and Landry 2008, Ward 2011). Liberty, however, may have different meaning in the Chinese context. Instead of liberty towards their own needs, *liushou* women may emphasis more on the liberty of controlling their family finances. While their husbands are not around, they need to plan the family spending and ensure the earnings are well spent. This also explains why sufficient cash and savings have positive affect to their happiness. Optimistic personality may compensate to a certain degree in poorer economic situations. Self-realization and the liberalization in the term of Western understanding did not appear to be significant with *liushou* women as they see their value by keeping the family well off. *Liushou* women may have provided a good example to demonstrate the cultural differences between the Chinese and Western cultures. The Chinese culture emphasises on the interest of groups than individuals, personal values need to obey the group interests. The Western culture can be traced back to the Renaissance. The guiding ideology of the Renaissance is humanism, namely upholding individual-centeredness, publicizing arch individualists, striving to develop self-expression. Western culture reflects individual cultural characteristics, which advocates personal values over group interests. Chinese group culture attaches great importance to families and friends, and put them as of society cells; while in Western countries, it advocates independence and self-reliance.

5 Conclusion and Recommendations

The formation of *liushou* women in China has its roots in the current economic situation, the cultural heritage and the strict *hukou* (residence management) system. This study investigated the factors that significantly affect the happiness of *liushou* women in rural Western parts of China. Factors include financial situation of the family, optimistic personality, government efficiency, conjugal relationship and relationship with in-laws were all significantly affecting the happiness of *liushou* women. The personal needs, such as self-esteem and actualisation become less importance when compared with the needs of the family. The drive of taking the family out of poverty through family teamwork is one of the common phenomena in rural China. Based on the findings from this study, the following recommendations are made aiming to improve or enhance happiness *liushou* women.

Measure one   reduce the obstacles of separating liushou women and their husbands for too long.

The study defines *liushou* women as with minimum period of 6 months each year of separation from their husbands. Conjugal relation is one of the key factors influence the happiness of *liushou* women. To make improvement towards such factors, we would propose of introducing measures to reduce the obstacles to allow them to meet more freely

by removing the difficulties which prevented them to meet up. Existing legislation, such as "Labour Law" specifies the benefits for labours entered into contractual obligations. It should be made clear that the labour forces coming from the countryside, i.e. the husbands of *liushou* women, should be made aware such benefits. Other difficulties such as costs, children's education, and social care services for elderly should be looked into carefully.

Measure two   provide training for liushou women to improve technical and social skills.

Provide free training for *liushou* women on various subject areas might be useful. The topics could include basic IT skills which would improve their information sources as well as improved communication with their husbands. Other topics might be how to communicate effectively with people at different level, how to manage personal and family finance, basic health care information, and basic scientific knowledge on agriculture.

Measure three   improve social benefits for liushou women who look after children and elderly.

Family economic condition has a significant effect on *liushou* women's happiness. However to increase the earning and protect the rights of migrant work are not the scope of this study. We propose, however, a better coverage of social benefit towards the families with *liushou* women, especially for the ones who look after young children and elderly people. Child benefit and social care homes might be good measures for the Chinese government to examine carefully.

Measure four   improve efficiency and attitude of government officials when handling enquiries from liushou women.

Government officials are not specially trained to deal with this group of people at a professional level. In most cases, these officials may not behave as social servants; they may act as masters instead. Lengthy approval processes and over complicated bureaucratic systems may add to the unhappiness of *liushou* women. It is therefore evident that to improve the happiness of *liushou* women, it is important to improve the efficiency and the attitude of civil servants towards them. All government offices should also make the public clearly understand their benefits and duties on health care, education, housing benefit, and welfare.

This research was based on intensive interviews which involved lengthy and complicated planning. Due to the limitation of time and resources, the sample size of this study was rather small. However the initial findings of this research may still shine some light on the understanding of this special group of women who are playing a significant role at the current economic and social aspects of rural China. One of the important finding from this research is that these *liushou* women are all willing to sacrifice the quality of their personal life to the happiness of their family, i.e. to improve the economic situation.

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RESEARCH PAPER

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Actor, Customary Regulation and Case Study of Collective Forest Tenure Reform Intervention in China

Yaofeng Luo · Jinlong Liu · Dahong Zhang · Jiayun Dong

Abstract The newly implemented collective forest tenure reform (CFTR) in China is a remarkable part of the global trend of forest management decentralization. This paper illustrates how local communities respond to the reform and how the various actors translate the policy principle into action under local social ecological condition in two case villages in Wuyuan County of Jiangxi Province in China. In the policy implementation of the CFTR, various actors, including local government, communities and villagers try to deconstruct the policy text, such as reform plan, forest distribution criterion and Forest Tenure Certificate system, with their own knowledge system. The cases of CFTR in the villages in Wuyuan County suggest there are major inconsistencies between national forest policy intervention and the local practice system. The traditional resource management system, which is based on the social customs in the local communities, is also effective to solve the collective action problem and contribute to efficient resource utilization. Thus the complexity and robustness of forest tenure combinations may ensure flexibility for sustainable forest management and accommodate the change of socioeconomic conditions.

Keywords Community forestry · Collective forest tenure reform · Policy implementation · Forest governance · Traditional knowledge

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Introduction

Over the last 50 years, academicians and practitioners have made great efforts to end "The Tragedy of The Commons" (Hardin 1968), while using approaches of "The Logic of Collective Action" (Ostrom and Nagendra 2006) and actor-centred power methods (Krott et al. 2013). In practice, decentralization of forest tenure has been prevalent as a mode of community forest management in south Asia (He et al. 2012; Singh 2013), Africa (Hartter and Ryan 2010), and South America (Hajjar et al. 2012), as has community engagement in forest management in North America (Nygren 2005) and Europe (Kuchli and Blaser 2005), and private forestry including agroforestry throughout the world. The decentralization of forest management has resulted in improved forest management (Ricketts et al. 2010), reducing the impacts of deforestation and forest degradation through a power transfer to local actors (Ostrom and Nagendra 2006), improving local autonomy, facilitating stakeholder participation in decision-making (Agrawal and Ribot 1999), and improved overall livelihood (Liu 2006). However, outcomes of decentralization and the processes for achieving the decentralization of forest governance are diverse (Tacconi 2007), and highly context-specific (Ferguson and Chandrasekharan 2005). Decentralization may also have negative impacton forest management and rural development. For example, it may result in destruction of forests, elite capture, or the ultimate failure of both the forests and the farmers in the forests (Liu 2009). In the field of decentralized forest governance, the power of actors has been identified as a crucial factor (Yufanyi 2012). Forest policy at the grassroots level features complexity, and is an arena where local actors struggle for better livelihoods and to convey their perspectives and interpretations on forest management (Liu 2009). The actor-centered power approach was proposed to conduct power assessment of actors in the decentralization process (Krott et al. 2013).

Collective forests take up about 60 % of China's forest in terms of area. Most of these forests were contracted to individual households through implementing the "Household Responsible System" (HRS) in rural areas during 1980s (Liu 2006). Marginalizing individuals' rights and interests of collective forest tenure is one of the reasons of the low efficiency of collective forest management (Zhang and Zhang 2005). In 2008, China initiated a new round of collective forest tenure reform (CFTR), which has aimed to clarify ownership of forest land, to contract out use rights to forest land for periods of up to 70 years, and to reaffirm forest ownership to individual households, with official licenses issued to individual households. The reform's fundamental purpose was to develop secure forest tenure in order to increase forest quality and productivity, improve the welfare of farmers, and to provide incentive to invest in forests, upgrade the harmonization of rural communities, and reduce corruption (Jiang 2006). However, in the course of decentralization, many issues of concern have emerged including lack of a participatory process, land fragmentation (Song et al. 1997), elite capture (Liu 2006), environmental degradation and need for improved management of small-scale forests.

Improving the responsiveness of forest management to the needs of various actors has become a primary issue. One essential item which requires further

investigation within the reform process is the perception of "top-down" policy on behalf of various local community actors, and how to adapt actions to best suit local and regional environments. The actors involved in the forest tenure reform are primarily local governments, local communities and villagers. This paper adopts an actor-oriented approach to investigate the following questions: How do the three groups of actors recognize and interpret the CFTR policy? How do these actors behave and take actions according to their knowledge? And finally, how do these actions shape and interact with the national policy? This study is designed to promote understandings of the local forest governance and policy transformations during the current process of forest reform in China.

Actor's Action Related to CFTR Intervention: Theoretical Framework and Research Question

It is widely accepted that forest governance at a community level is subject to a wide diversity of social and economic conditions (Agrawal and Ribot 1999). Implementation of forest tenure reform on the ground is highly complicated with many issues, involving power structures, customary regulation, cultural heritage, and conflicts of stakeholder interests within and between communities and other stakeholders (Fig. 1). This always leads to much disparity between the policy needs of local people and policy interventions by government.

Forest use and ownership on the ground are arenas of conflict and struggle, involving various actors who compete for benefits and struggle to pursue their own interests. Different actors always tend to take strategy action based on their policy interpretation, while suffering from the diversified power-structure and arrangements due to the uneven distribution of economic capital, social network, political relationship, institutional power and labour capital.

In practice, many forest management issues often arise due to the differing propositions from local communities, social investment and global markets. The result of forest reform policy implementation also lies in the wider context of rural development, rural governance, community participation and traditional livelihood.

Actors' actions related to CFTR intervention issues involve both power structure and stakeholder interest. The successful implementation of CFTR needs to consider all the forest management and rural development issues. However, in this paper, research emphasis is put on the actor's interpretation on the CFTR intervention based on their differing knowledge systems.

The broad research question that guides the analysis in this paper is 'When confronted with the intervention of CFTR, how do the various actors interpret the policy and take action based on their own knowledge system?' Different stories told by different actors and stakeholders reflect their unique interpretation on the CFTR issue. Three more specific sub-questions arise:

Sub-question 1. 'Will the local government implement the tenure reform policy in accordance with the central government policy? How will they interpret the forest tenure reform program into local practice?'
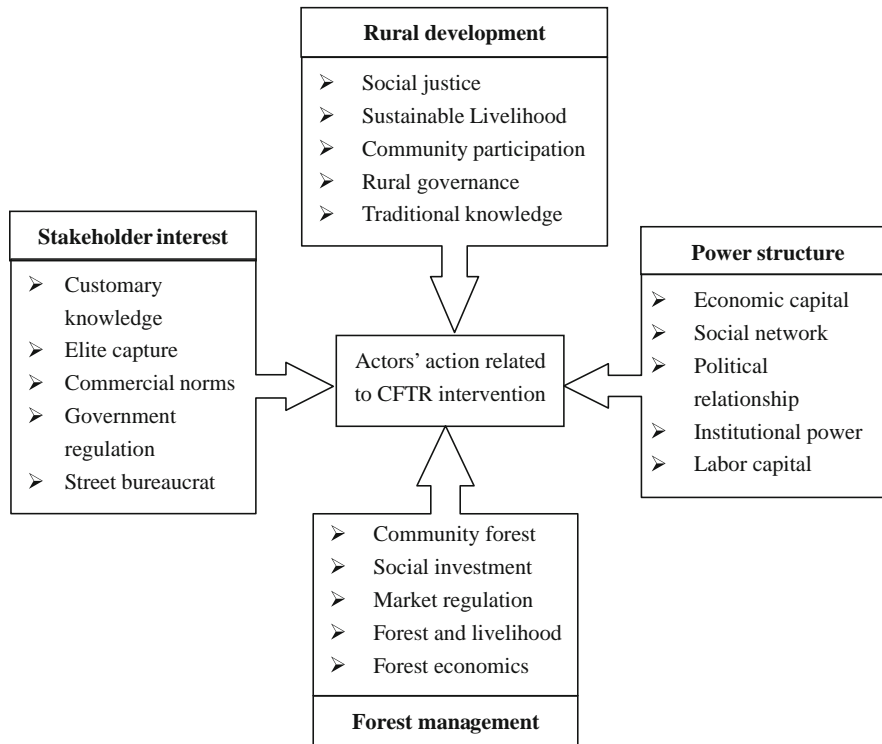
Fig. 1 Theoretical framework for actors' actions related to CFTR intervention

Sub-question 2.   'What is the role and impact of local village customary regulation on the outside intervention of CFTR, especially on the forest allocation criterion issue?'

Sub-question 3.   'What are the local villagers' perceptions of the intervention of CFTR, especially the forest distribution methods and techniques adopted in the reform (e.g. satellite imagery, forest certification)?'

The Study Area

The study area consists of are two administrative villages—Hong and Taoxi—in Wuyuan county in north-east Jiangxi province in Southeast China (Fig. 2). Jiangxi Province features a high level of forest cover (63.1 % in 2013), amongst the highest in China, and was selected as one of the four provinces out of 31 provinces to pilot the new round of collective tenure reform by the central government in 2004. Collective forests comprise 65 % of the total 1 million ha of forests in Jiangxi province.

According to the forest resource survey data in 2009, Wuyuan County has forest coverage estimated at 83.8 % of the land base. The county officially commenced the
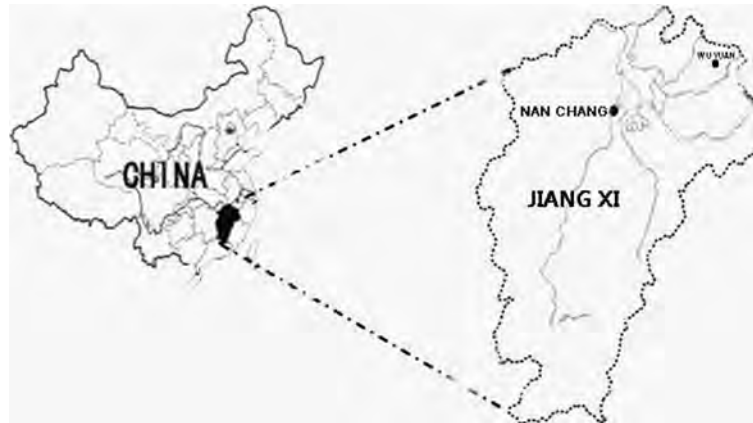
Fig. 2 Location of research site (Wuyuan County)

CFTR process in May 2005, and accomplished the reformation in the span of just over 2 years, with completion at the end of 2007. A total of 80.6 % of forest land, or about 25,000 ha, has been redistributed to individual households, and the government has issued 206,600 forest certificates to these households based on an official report released by Wuyuan Forestry Bureau 2009.

Both of the two selected villages are rich in forest resources (Table 1). Hong village, in the southwest of Wuyuan County, has 2,533 ha of forest land, 42 % of which is designated as ecological forests and promotes forest tourism. Taoxi village, with a population of 2,300 people in 512 households, occupies 2,400 km^2 and contains a total forest land base of 3,162 ha.

Research Method

The implementation of CFTR policy in local communities involves many actors, including governmental and non-governmental institutions and individuals. Here major actors were grouped into three categories, local government, community and famers. Local government includes governmental institutions at county and township level and officials or technicians employed, which are usually the major body for policy set up and implementation. Local community includes village committee and party committee, and people in these committees. Local farmers include farmers' association and householders who have relationship to these communities.

The field data collection was carried out from July to September in 2010. Qualitative methods were used in the data collection, including observation, interviewing, field survey and group discussions with details as followings:

1. Meetings and interviews with governmental authorities. Visits were made to the forestry bureaus at province, county and township level in Jiangxi province.

Table 1 Basic information of the study villages

Village	Population	Number of households	Area of paddy fields(ha)	Area of forest land (ha)	Percentage of ecological forest in total (%)	Percentage of plantation in total (%)
Hong	1,513	346	93	2,533	42	58
Taoxi	2,300	512	197	3,162	51	49

Government official files were collected, including the final version of the forest tenure reform reports and implementation manuals in the three levels of forestry bureaus. The officials in charge of CFTR were interviewed about how they carry out the CFTR, how they intervene in the process of CFTR implementation, and their recognition of and attitude to the CFTR policy, with a semi-structured questionnaire.

2. Interviewing key informants in the communities. Semi-structured interviews were carried out with key informants, including village elites, elders, heads of various forest management units and village heads. These key informants are usually story tellers, organizers and actors in village activities and festivals, carrying out analysis of historic events, village regulation, and changes of forest management styles. Files related to the CFTR, including the detailed forest tenure reform plan, were collected from village heads.

3. Household survey. A random sample of 100 householders was selected from the two villages. Key questions were prepared about information related to household members, and recognition of the CFTR policy, including perceptions of the process of the CFTR plan in the village and how their livelihood and forest management changed after they received their Forest Tenure Certificate.

4. Group discussions with residents including elders and youth, both male and female, in every study villages. The group, including eight people who were familiar with the CFTR issues, with instructions drew village land-use maps, forest-management maps and historical timelines to identify issues and map out past events related to collective forest reform. During group discussion, visual tools—including participatory mapping, ranking and historic recording—were used to conduct analysis with community people. The group discussions were also designed to cross-check data collected by key informants and facilitate a debate on advantage and disadvantage of the collective forest reform.

The "actor-oriented approach" as described by Long (2001) was applied in the data analysis. In this approach, each actor displays practices and interests within a local context, which are closely integrated with social relationship networks and traditional customs (Long 2001).The case-study materials were considered in the context of specific events and processes, using the explanatory methodology in the analysis period to develop an understanding of local policy implementation.

Results

Local Government's Interpretation on the CFTR Policy

As usual, CFTR as one of central governmental initiated policies was implemented by a top-down approach through the administrative system. Upper-level authorities provided a lot of training and shared learning opportunities. Wuyuan County Forest Bureau as a forest agency was responsible for implementing this policy in the county, and spent a few months advocating this policy, which is required by central government. According to the guidelines for CFTR policy implementation, farmers are the major stakeholder to be mobilized to participate in the implementation. However, de facto, this is a dialogue or negotiating process between communities and the governmental authority, with tradeoffs among county authority and township authority. National policy texts are firstly interpreted by local bureaucrats upon their entry into local communities, as one of the forest officers in Wuyuan County Forest Bureau stated.

> The implementing plan of the tenure reform program in Wuyuan County was developed in the period of one and a half months, during which the local governments held seminars 15 times, solicited opinions from the province and city inspectorate's opinions twice, and revised the texts drafts 17 times. We decided that forestry cooperation organizations are very practical for our mountain areas.

The final draft of the CTFR plan in Wuyuan County stated the principles to "distribute shares not forest lands, and primarily distribute profits not forests, while supplementing by allocating forests to households" for CFTR implementation. Their plan was challenged by the provincial forestry authority because it is clearly required that over 90 % of collective forests have to contract with individual householders. The implementing principles and forest cooperation organization as a main unit for forest management are not supported by the policy issued from the State Forestry Administration.

The county authority put forwards three arguments in response the concerns of the provincial authority, as stated by local forest officials:

> We firstly cannot deal with the workload if we are to distribute forests to every household in no less than 2 years. And such work may even exceed our funds and manpower ability. Secondly, national policy is unlikely to be feasible. Nowadays, peasants all want the forests they gain to be 'good forests', while nobody wants the 'bad ones'. How is it possible to distribute forests equitably? If we follow the national policy, too many factors will affect our allocation plans, including the distance from mountains to the village residences, and which parts of mountains will be reallocated. Who gets the higher parts of the mountains, and who gets the lower parts? Lastly, problems exist in fireproofing. When we plant forests, we burn branches and leaves to generate fertilizer. If the gap area among households' forests is too small, it's likely to

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be the cause forest fires, and relatively difficult to handle, which is also a restriction.

A CFTR policy implementation report made by Wuyuan County Forestry Bureau said, according to the survey, farmers were in favour of distributing all collective forests to individuals. However, county forest officers put forwards some political discourses to support their approach of "distributing shares not hills" as the main reform model.

> Taking funds, labour power and aspects of social stability into consideration, pamphlets of reform in the county clearly point out that our county is the key forest district and tourist county. The forest is the foundation for economic development, and the main source of primary income and even the backbone of economy. And the forest is not only related to the interests of peasants, but also the source of incomes of forest cadres. Only the stability of the forest industry can lead to the overall peace in the society of Wuyuan County.

The statement shows that local governments tend to carry out national policy according to the "local conditions", and are not always acting in coherence with the guidance of national forest policy. These local governments act according to many factors, including local government ability, restrictions imposed by funding and manpower, technical difficulties and social considerations, to implement collective tenure reform policies. This phenomenon indicates that the local governments have their own understandings of national policy, and when it possibly threatens local governance and benefits, local governments tend to find reasons for policy modification by the means of "grumbling". If the local policy modification can lead the national policy to benefit local villagers, it is likely to be effective. Otherwise, the unilateral action of local governments will work to support the idea that "good national policy cannot lead to good practical outcomes".

Role of the Local Communities' Customary Regulation on the CFTR Policy

In the process of collective forest tenure reform, a key issue is how to define who have the rights to obtain forest licenses. The survey reveals that most county governments regard household registration as the basis of contract rights, which means peasants who possess village membership are legally entitled to contract collective forests. For instance, the forest tenure reform program released by Wuyuan County states:

> (Forest tenure allocated objects) include all members in the village collective. Generally speaking, objects refer to local villagers and their children who automatically obtain membership qualification. In addition, as to persons connected by marriage, adoption or immigration who obtains memberships, the currently available household registers are effective. The self-reserved mountains and contracted mountains keep the same contacting objects. In defining tenure of collective forests, household registers on the payroll act as the main basis.

The governmental approach of identifying membership is what is in the law. By law, people who has been registered in a village can be accepted to be members of this collective, who automatically have rights to share collective property. However, when thoroughly investigating in Hong village, it was found the village adopts another more complicated proposal, related to their internal criteria for classifying village membership. The identification of membership rights of the "forest distribution" program in Hong village is summarized in Table 2.

As shown in Table 2, the rule of villagers' membership identification is not in adherence with the national registration system, and it appears highly complex and difficult to understand for outsiders. These rules are an "oral" agreement without a written form of protocols, and represent knowledge that is only held by local villagers. Thus the national government experiences difficultly with regard to this complicated traditional knowledge of local communities, in that these rules are not suitable to popularize, are difficult to define and may not be substantiated within the legal system.

In contrast to the legal system, the local communities' traditional knowledge about the local property rights systems appears to be robust and effective. This is perhaps because the local membership identification system has developed in the context of villagers' daily lives, and is widely established and recognized within the village. This system is generally acknowledged by all villagers and conforms with the common sense, habits and livelihoods of villagers, thus acting as a functioning example of self-governance. Thus it is advisable that the implementation of national forest policy should put more emphasis on the traditional knowledge systems of local communities.

Villagers' Recognition of the CFTR Intervention

According to the national forest policy, after demarcation of the forest land, Forest Tenure Certificates should be issued to householders. The content of the Forest Tenure Certificate includes the forest tenure owner, property rights, forest management style, location of forest land, four boundaries of the forest land, land area and map. The demarcation method of forest tenure was described by Taoxi villagers as follows:

> They used the satellite image to map out the forest land and confirm the area in the forest tenure reform. Initially, they drew lots among villagers in our community to distribute forest land sequentially by the lots. Then the staff of the forestry administration department went up into the mountains to map out every household's forest land and recorded these. And small squares were drawn on the satellite Contour Map, representing the area. (The satellite imagery has a ratio of 1:100,000, 1 cm square = 1 hectare of forest land).

Forest Tenure Certification is highly important for the farmers' daily activities. The advanced Forest Tenure Certificate system was said to be of great significance for applying for thinning or logging permits, obtaining a temporary bank loan, transferring ownership (use rights) and consolidating forest management, and it has been energetically promoted. However, from interviews with villagers in Taoxi

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Table 2 Forest allocation criteria by customary regulation in Hong village

Category	Whether to be allocated forest land	Villagers' customary membership regulation	National law regulation
Sons in law (married in)	No	They are not native	Yes, if they have the village residential registration
Daughters in law (married in)	Yes	They will belong to the village	No, if they don't have the village residential registration
Women from the village and married to outsiders	No	They do not belong to the village any more	Yes, if they have village residential registration
College students	Yes	They are not capable of earning their own living	No, if they don't have village residential registration
Graduates from colleges without jobs	Yes	They may return back for farming	No, If they don't have the village residence registration
Graduates from colleges with jobs	No	They are able to make a living outside the village	Yes, if they have village residential registration
Villagers who change their dwelling place to outside the village	It depends on whether they can make a living outside	The rights to forests are a last safeguard for them	It depends whether they have village residential registration
Villagers in prison	No	They no longer belong to the village	Yes, if they have the village residential registration

village it is apparent that there is a great disparity in the recognition of the Forest Tenure Certification System versus the local community knowledge system. The farmers have their own recognition system for important items, such as the forest land boundaries, area and maps, which is reflected in the following statement:

> Sure, the Forestry Tenure Certificate is good for our forest management. But we cannot really get clear details about the satellite contour maps on those certifications. Those zigzag lines confuse us and also are imprecise. We can get clear information only by going up into the hill to see the forest land boundaries by ourselves.

Thus a question arises: 'When the official forest tenure registration system attempts to incorporate the communities' property ownership system into the modern management system, why does this effort always result in the failure of merging the two systems?' Answers to this question can be listed as follows:

1. The Forest Tenure Certification System can simplify the forest land rights through accurate descriptive data, but may ignore some of the complexity within land-usage rights that exists in reality. For example, some traditional public forest land ownership cannot be displayed fully through the Forest

Tenure Certification System. Despite this shortcoming of the official tenure system, locals are familiar with these traditional knowledge systems, and they can master subtleties of the systems for their own purpose, as the villagers in the Taoxi community described:

We always went up into the hill to visually draw forest boundaries by ourselves, and we know clearly who owns which part of the forest land. The visually measured land area is likely to be not so accurate because of the rugged hill topology, but it matters little to us. The neighbours are nice in our village. Usually, several householders work together when we need to cut down and sell trees, and the benefit is shared based on the number of family members. In this way, the precise forest land areas make little difference to us.

2. The forest tenure registration system reflects only the land ownership arrangements related to administrative purpose at the time of action. Buying and selling means that land ownership is being continuously adjusted, and land usage is always changing. These changes have accumulated to the extent that the forest tenure system is no longer clear, and thus there is a need to renew statistical data repeatedly for an indefinite time period.

3. The satellite maps used for the forest registration system are inaccurate. These maps are geometrically-shaped, ignoring the land's boundary corners and curves and even ignoring the varied local conditions. Based on these maps, governments can outline the entirety of forest land properties, and provide a standardized application for the whole country. However, these maps record only statistical data on the quantifiable forest land area and value, and lack the concrete details about the land. A farmer said:

Actually, the satellite methods used in the Forest Tenure Certificates are unreliable, and the map is unclear, because our forest lands boundaries cross. Thirty acres of forest land was supposed to be distributed to me, but after the mapping and measurement, in practice, I finally received only 26 acres.

These government maps merely show the boundaries geometrically, which differ considerably from the real boundary locations of the forest land ownership. They generally rule out many factors involved in the consideration of ecology and local livelihoods, and do not work to reflect the real, and emotional, experiences of peasants and local practices.

4. The new forest tenure system is easy for governments to use, and it can meet the needs of outsiders who want clear and general information about the local community. Government officials sitting in offices can swiftly access information to manage forest through official documents, which can be validly applied in the national legal system. However, peasants are reluctantly involved within these unfamiliar systems, such as contracts, legal assessments and applications. Therefore, even though these systems can be easily created and accessed, they are difficult to put in practice in reality, and may not have the intended effects in the context of a local community. The Forest Tenure Certifications are always "placed at the bottom of boxes" and hardly become recognized by the local

communities. Peasants intuitively understand that "these files can only be used in lawsuits" when needed to protect their land rights, as stated by one of householder in Hong village:

We usually place the forest tenure certificate in the bottom of box and we don't use it in our daily lives. The map only assists in disputes, which can be used as evidence in lawsuits. We work within the forest land boundaries accepted by everyone in this village community. We don't calculate the area. We just record the number of trees when we plant. And every householder complies with our internal regulation.

In fact, the Forest Tenure Certification is only one of the measures which contribute to improve forest property protection. But in the view of the local tradition, local property arrangements and customary institution systems may be much more important in the implementation of sustainable forest management.

Conclusions and Policy Implications

Actor's Agency in Policy Implementation

Based on a thorough understanding of the cases of the CFTR in China, it is necessary to apply the concept of agency of actors to deepen the understanding of the forest governance issues in the local community. The actors are able to interpret and shape the forest policy based on their agenda and interests.

When the national forest policy is implemented in the community, the policy text cannot be considered to deliver only a single piece of information. Various actors interpret their own meanings of the text, and would then form their policy interpretation and reconstructed action plan based on their own action strategies.

Individual actors formulate their own action plans based on their own action strategies with the intervention of CFTR, which these actions usually differ greatly between the various actors. It is one thing to have a good forest policy, but how the policy is implemented into grounded policy action is another matter. Understanding actor's behaviour and agency is critical.

Policy Elements in National Official Document and in Implementation

The cases of CFTR in the villages in Wuyuan County show there are large inconsistencies between national forest policy and local practice. Firstly, the transparency of property rights that the national policy requires may create prejudice against the interests of some social groups, including the interests of the local government. This leads to the local governments' tendency to reconstruct the national policy text based on their own interpretation. Secondly, local practices, such as the customary regulation of membership identification, the traditional forest

land property right system and community resource management, are always complex and diverse, which is inconsistent with the clarity required by the national policy.

This phenomenon of large inconsistencies between national policy and local practice reveals that, even though the national policy attempts to bring the local society into the management scope of the modern knowledge system, the local knowledge system may deconstruct these efforts to some extent.

From the perspective of so called "advanced" administration of society, the CFTR policy and some modern systems (such as the household register system and the forest tenure register system) are effective for promoting social management and statistical analysis because of the their highly abstract nature and universality. In contrast, the local traditional property rights and the customary regulations are somewhat vague in practice. From the national administration perspective, the variety and complexity of these localized systems does not work to ensure the state's benefit, but purely the benefit of the locals, and thus it is challenging for these systems to be adopted by the state's management system.

Although the state makes great efforts to transform society, there still exists much confusion and many impediments in the process of the local communities' deconstruction of the national policy. In modern society, the state assesses particular aspects of social life through some symbolic systems, but the statistical data from these symbolic systems diverges from what is occurring within the real society (Scott 1998). Comprehending the disparity between the truth in the policy text and the real practice in the local environment is important. It cannot be assumed that the local practice will always be consistent with the logic utilized in national management.

Reflection and Policy Implications

The case studies demonstrate that local knowledge and practical norms are hardly disturbed by external knowledge systems. Policy implementation and forest governance practice in the local communities is likely to be revealing for forest reform in China and the process of forest decentralization around the world.

Because the national policy intervention may influence the traditional knowledge systems of local communities, it is reasonable to coordinate the actions of various actors, such as local governments, communities and individuals, in the forest tenure arrangement. With continuously changing socio-economic conditions, the complex and robust nature of combined forest tenure systems and governance may ensure flexibility within sustainable forest management (SFM), so that management may become increasingly adaptable to socioeconomic changes.

The forest tenure transition is just one of the inducing factors for SFM (Doornbos et al. 2000; Liu 2007). The complex traditional resource management system based on social customs in the local communities is also effective in overcoming the "The Tragedy of The Commons" problem and contributes to efficient resource utilization (Liu et al. 2012). In the forest management process, no matter how kind and insightful the external intervention is, once the community customs and collective arrangements become altered by external forces, the forest is more likely to

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experience damage, locals' livelihoods are more susceptible to corrosion, and the overall welfare resulting from an external initiative is likely to be reduced.

As observed in the case study, when the national forest policy undergoes implementation in a local community, the various stakeholders try their best to interpret and shape the policy based on their own understanding. Many disparities in knowledge exist between local practices and the management logic of the state. Therefore, more in-depth studies on local knowledge systems are necessary, and the differentiated action mechanisms of various actors in the local community require more attention. In the policy formulation and pilot period, more actors and stakeholders should be involved in the discussion and negotiation process. The participatory decision-making processes within local communities among various stakeholders are always of great importance to local forest governance and sustainable forest management.

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The implementation and impacts of China's largest payment for ecosystem services program as revealed by longitudinal household data

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ABSTRACT

As the largest payment for ecosystem services initiative in the developing world, China's Sloping Land Conversion Program subsidizes households to restore marginal croplands and other degraded fields. While it has attracted broad attention, many questions regarding its performance remain unanswered. Using descriptive and econometric analyses based on a longitudinal dataset containing a large number of surveyed households over 1999–2008, we examine the multi-faceted changes in program enrollment, land and labor allocation, agricultural production, and income structure and inequality. We find that the program has affected land use substantially by simultaneously retiring degraded cropland and increasing forest and vegetation covers, which have accelerated labor transfer into off-farm sectors. Meanwhile, households have intensified agriculture by increasing their production expenditures, enabling them to offset some of the negative effects of the cropland set-aside and reduced farm labor use. While the subsidies have been a significant source of income to the participants, most households have had a larger portion of their income come from non-farming jobs, leading to the increase of average family income by over 250%, and the reduction of rural poverty and thus the most vulnerable population. As impressive as these changes may be, the program still faces great challenges before the ecosystems are adequately recovered to provide their services.

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Introduction

Driven by population expansion, economic growth, and poor governance, among other factors, China's terrestrial ecosystems experienced tremendous destruction during the second half of the last century, as evidenced by the depletion of primary forests, the deterioration of vast grassland, and the degradation of fragile cropland (Liu and Diamond, 2005; Wang et al., 2007; Yin, 2009). These trends led to worsening soil erosion, wildlife habitat loss, greenhouse gas emission, and many other environmental problems; meanwhile, people's livelihoods were adversely affected, as indicated by the incidence of poverty, food insecurity, and the high rate of joblessness (Xu et al., 2006; Uchida et al., 2007). To tackle the challenges, China has been undertaking several major ecological restoration programs since the turn of the century, including the Sloping Land Conversion Program, the Natural Forest Protection Program, and the Desertification Combating Program (Wang et al., 2007; Yin, 2009).

As a primary initiative of payment for ecosystem services (PES), the Sloping Land Conversion Program (SLCP) subsidizes farmers in mostly poor rural areas of western China to retire marginal, sloping cropland and other heavily degraded fields and restore them to forest and vegetation covers (Liu et al., 2008; Bennett, 2008; Cao et al., 2009). Because of its huge public investment (over 430 billion yuan), along with its broad geographical coverage (25 provinces and autonomous regions) and participation by rural households (over 30 million), the SLCP has become the largest PES program not only in China and but also in the developing world (Liu et al., 2008; Bennett, 2008). It is expected that in addition to improving China's own environmental conditions, this and other PES programs also will benefit the rest of the world in terms of climate change mitigation, biodiversity protection, and duststorm control, to name a few (Daily and Matson, 2008; Yin, 2009). Even though the SLCP has

been implemented for more than a decade, however, a lot of the program detail in terms of participation and enrolment, land and labor allocation, agricultural production, and income structure and inequality, remains poorly understood. This paper aims to fill these salient knowledge gaps by presenting a comprehensive profile of the program and a careful econometric analysis based on a large longitudinal dataset of household surveys.

The environmental aspiration of the SLCP is to increase the country's forest and grassland covers and thus reduce soil erosion, flooding, and desertification and other ecological disasters by primarily retiring and converting marginal, sloping lands from farming. The original target of cropland set-aside was set at 14.67 million hectares (ha) by 2010. Further, a comparable amount of abandoned farming and grazing fields and even denuded lands on hillsides was included for voluntary forest and vegetation recovery. Another goal of the program is to reduce poverty and promote rural development (Uchida et al., 2007; Yin and Zhao, 2012). According to the original program stipulation, farmers would receive a grain subsidy of 2.25 tons/ha (150 kg/mu) per year for retiring and restoring their cropland in the Yangtze River basin and 1.50 tons/ha (100 kg/mu) per year in the Yellow River basin.[1] Thus, the program also has been known as the "Grain for Green Program" (Li et al., 2011; Uchida et al., 2009) and the "Grain to Green Program" (Liu et al., 2008). In addition, a cash outlay of 300 yuan/ha per year would be provided for farmers to purchase seeds or seedlings and to conduct tending activities.[2]

On paper, the subsidy duration would be eight years if environmentally benign trees are planted mainly for providing ecological functions and services; five years if commercial trees are established for producing timber, fruits, nuts, and other products; and two years if grassland is rehabilitated. In reality, however, most of the retired cropland has been planted with trees of mixed species and enrolled for eight years. This is because of the biased preference of the State Forestry Administration (SFA), who is in charge of implementing the program, toward tree-planting on the one hand and participating farmers' desire to get government subsidies for a longer duration on the other (Yin and Yin, 2010; SFA, 2009).

Since its initiation in 1999, the SLCP has undergone substantial modifications. First, due to dwindling public reserves, the gain subsidy was abruptly phased out by 2004 and replaced with a monetary compensation by setting the grain price at a constant rate of 1.40 yuan/kg (Yin and Yin, 2010). Related to this change has been the significant scale-back of the program due to concerns with national food security (Yin et al., 2010; Bennett, 2008). Moreover, because many participating farmers still had difficulty finding alternative job and income sources to improve their livelihoods, the State Council decided in 2007 to extend the program for another round—until about 2020. At the same time, the primary component of the subsidies—compensation for lost grain yields—was halved to 1575 yuan/ha a year in the Yangtze River basin and 1050 yuan/ha a year in the Yellow River basin, respectively.

As shown in Table 1, the SLCP already slowed considerably in its implementation after 2003 and almost came to a complete halt later. By 2008, it retired and converted 8.0 million ha of cropland, less than 60% of its original target; it also established forests on another 4.2 million ha elsewhere. Given that, obviously, the original target of cropland retirement has not been achieved. Nonetheless, it remains true that the SLCP has led, among other things, to a substantial increase in China's forest and grass covers, along with a marked reduction in cultivated land (Yin and Yin, 2010; Li et al., 2011; Bennett, 2008).

Table 1
National statistics for the SLCP implementation.

	Forestation on retired cropland (1000 ha)	Annual investment (1,000,000 yuan)	Afforestion elsewhere (1000 ha)
1999	381.5	335.9	211.6
2000	328.4	1540.8	280.3
2001	386.1	3145.5	217.3
2002	2039.8	11061.0	676.4
2003	3085.9	20855.7	824.4
2004	824.9	21429.1	473.3
2005	667.4	24041.1	408.3
2006	218.5	23214.5	409.5
2007	59.5	20840.9	315.1
2008	2.2	24897.3	469.0
Total	7994.2	151361.8	4285.2

Data source: China Forestry Development Report (SFA, 2009). The exchange rate is $1 = 6.3 yuan in January 2012. The consecutive growth of the annual investment is driven by the multi-year durations of the subsidy schemes.

The most relevant measures of the performance of the SLCP are its efficacy of implementation and significance of impact (Yin et al., 2010). Implementation efficacy refers to what the program has achieved in relation to its operational targets, whereas impact significance concerns how a program's execution has served its ultimate goals (Parris and Kates, 2003). The former can be gauged with such indicators as land area converted or conserved, effectiveness of site selection and preparation for tree/grass planting, survival and stocking rates of vegetation rehabilitated, and cost savings relative to the budgeted expenditure for a given task. The latter can be elucidated by the induced environmental and socioeconomic changes (Ostrom, 2007; Yin, 2009). The former are reflected in ecosystem functionality and stability, such as the status of erosion control, biodiversity conservation, and carbon storage; the latter are represented by such indicators as poverty reduction, income growth, and labor transfer. Thus far, a majority of the studies assessing the SLCP have concentrated on evaluating its short-term, local socioeconomic impacts based on household survey data, as well as its implementation efficacy (Yin et al., 2010).

In addition to overviewing the early SLCP implementation and discussing the challenges it encountered, several articles have reported the induced short-term, social–ecological changes using secondary evidence and/or government statistics (Wang et al., 2007; Liu et al., 2008; Yin and Yin, 2010). Meanwhile, empirical analyses of the socioeconomic effects have begun to appear in the international literature. For instance, Uchida et al. (2007) identify a moderate success of the SLCP in achieving its poverty alleviation goal, and Uchida et al. (2009) further show that participating households are increasingly shifting their work time from on-farm to the off-farm labor market, with the effects dependent on the initial level of human and physical capital. Yao et al. (2010) find that the effects of program participation on incomes from crop production, animal husbandry, and off-farm work vary a great deal, and these effects are mediated by local economic conditions and political leadership. Likewise, Groom et al. (2010) study the effect of program participation on labor reallocation toward off-farm activities and find heterogeneous effects. Mullan et al. (2011) further examine the role of incomplete property rights as well as participating in the SLCP in the migration decisions of rural households; their results indicate that tenure insecurity reduces migration, but participating in the SLCP does not increase migration significantly. Li et al. (2011) also demonstrate that participation in the SLCP has significant positive impacts on household income, especially for low- and medium-income families; and income inequality is lower among participating households.

As interesting and insightful as these findings are, one common limitation of the previous studies is that their sample size is small

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[1] Note that mu is a Chinese measure of land area and 1 mu = 1/15 ha.

[2] 1 US dollar = 6.3 yuan, according to the exchange rate in January 2012.

and/or the time points covered are few. The two studies by Uchida et al. (2007, 2009) are based on a small dataset of about 350 households with three points of time being covered—1999, 2002, and 2004. While the dataset used by Yao et al. (2010) contains 600 households in three counties of the Loess Plateau region, it covers only two points of time—1999 and 2006. Similarly, the dataset used by Grosjean et al. (2010) has information on 155 households in Ningxia and 131 in Guizhou for only 1999 and 2003. The same dataset is used in Mullan et al. (2011), with the complement of another more forestland-centered survey of 285 households in Guizhou. Finally, Li et al. (2011) are based on 929 households from one county (Zhouzhi) in Shaanxi for 2007 only.

While it is costly and time-consuming to gather household data from large samples and difficult to accumulate long series with more consecutive observations, comprehensive data are an essential first step in generating reliable and robust empirical evidence and policy insight concerning the program implementation and impacts. As a result of the paucity of datasets with broader, longer, and more consecutive coverage, many questions concerning the performance of the SLCP have not been clearly addressed even after a whole decade since its initiation: How has the program been actually carried out in terms of the number of households enrolled and the amount of cropland retired and forests established? To what extent has it affected the local agricultural production and people's income, employment, and other livelihood measures? How are the government subsidies for cropland retirement and conversion compared to the lost farming revenues? Will a significant portion of the participating households likely reconvert their retired cropland back to farming once the program expires? Answers to these and other related questions are needed because they pertain to not only the effectiveness of the huge PES initiative itself but also the policy prescription for any future effort of ecological restoration and environmental protection in China and beyond (Tallis et al., 2008).

The objective of this paper is to address the above questions with a unique dataset that the authors have compiled from multiple rounds of surveys. The dataset, covering 10 years (1999–2008), contains more than 1200 households in six counties of two representative provinces in western China—Shaanxi and Sichuan. Here, we also take into account the broader context of China's rural economy and developments in the local institutional and policy arena in supporting the transition from ecological destruction to restoration. It is hoped that, in so doing, not only will our understanding of the SLCP be improved and myths surrounding it dispelled, but also issues relevant to policy and research can be more appropriately framed and explored in assessing the performance of this or another PES program. With the acute pressure for countries to restore their degraded ecosystems and build their natural capital assets (MA, 2005; Comin, 2010; Daily and Ellison, 2002) to improve service provision and livelihood support, China's lessons and experience hold broader international significance.

Data and methods

The data used in this article were derived from four rounds of household surveys based on a stratified random sampling strategy. Six counties were first selected from Sichuan and Shaanxi for survey, according to the geographic coverage of the program and the distribution of farmers' income as well as our knowledge of the general regional conditions. These two provinces were identified by the central government as pilot and primary sites for implementing the SLCP, the former being in the upper Yangtze basin and the latter in the middle reaches of the Yellow basin (SFA, 2009). The four counties from Sichuan are Nanbu, Nanjiang, Mabian, and Muchuan; the two from Shaanxi are Zhen'an and Yanchang (see Fig. 1). Then, townships, villages, and households were randomly
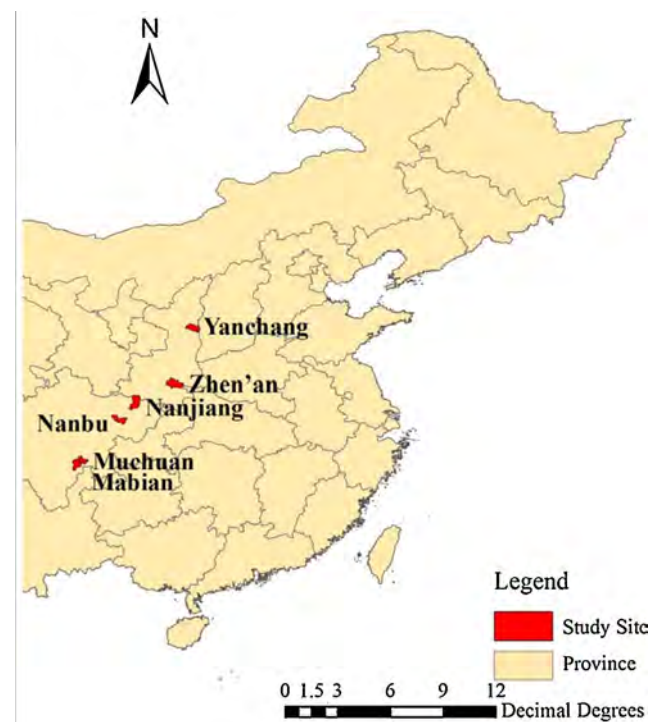
Fig. 1. Study sites (2 counties in Shaanxi and 4 in Sichuan).

selected in each of the chosen counties. In general, six townships were chosen in each county, three villages from each township, and around 15 households from each village. To ensure survey quality, pre-tests, focus group discussion, and enumerator training were conducted. The initial survey was carried out in 2001 as part of our program monitoring and assessment efforts (Liu et al., 2010[3]). At this first survey, we asked interviewees to recall their production activities and other relevant information back to 1999 when the SLCP was launched. Later, we repeated our surveys in 2003, 2005, and 2009 in building up our dataset.

It should be said that our surveys did not get complete information from all of the initially selected households in all of the years. This is because: (i) attrition resulted from some of the households having migrated to places other than the sample villages, deceased, or been disqualified; (ii) errors occurred in a small number of interviews; and (iii) a few families failed to clearly recall their production and employment activities in the previous year(s). These factors led to the gradual decline and slight fluctuation of the number of sample households, which began at 1447 in 1999, peaked at 1461 in 2003, and dropped to 1251 in 2007 (see Table 2). Nonetheless, our testing found little effect of this fluctuation on the sample representativeness.

Our dataset contains information on land status (participating vs. non-participating), parcel features (area, topography, and road access), subsidy payment (amount and starting time), family demographics (size, number of laborers, and household head gender, education, and ethnicity), on- and off-farm production and employment activities as well as expenses and revenues for both participants and non-participants, and individual perceptions of the program. Whenever possible, data entries were compared to local socioeconomic statistics from official sources to check their accuracy. In general, they deviate from the government statistics

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[3] Readers are advised to refer to this article for a discussion of the practical implementation of the program, including how an area is selected for participation, how a household is enrolled in it, and what trees are planted.

Table 2
Number of households in the sample provinces.

	Shaanxi	Sichuan
1999	531	916
2000	534	916
2001	534	919
2002	534	921
2003	534	927
2004	534	927
2005	537	912
2006	537	913
2007	472	779
2008	471	793

Data source: Authors' surveys.

by no more than 15%, suggesting a high level of reliability (Liu et al., 2010). Further, it can be argued that even if some elements of the data may not be highly accurate at certain points of time or in certain aspects, the trends embedded in the time-series can consistently shed new light on the issues of our concern. The nominal price, cost, and revenue information has been converted to real values using the provincial Consumer Price Indices, with 1994 as the base year.

Several technical definitions and procedures are now in order before presenting our descriptive and econometric results. First, the total number of enrolled households in a given year is the sum of the net annual enrollments accumulated over previous years. The net annual household enrollments are the balance between new enrollments and withdrawals in a year. Withdrawals, albeit rare, may result from family reasons (migrated to another place or deceased) or programmatic reasons (disqualified or no longer enrolled). Second, upon enrollment, a household promises to retire a certain amount of marginal cropland and plant it to trees or grass, or enclose it for natural forest or vegetation regeneration. In return, the household receives the specified subsidies from the government. So, the term "forestland" used here simply means any land designated for forest use following the initial restoration action. This is different from the official definition—a tract larger than certain size ($\geq$0.5 ha) with trees of certain height ($\geq$5 m) and canopy density ($\geq$10%) (FAO, 2010). Also, we did not get information for grassland because few households in the sample counties were engaged in establishing any grassland, an outcome of the combined choices of program authorities and participating farmers.

Third, agriculture includes grain and livestock production. Its expenses are for purchasing such items as seeds, fertilizers, pesticides, plastic mulch, feeds, and fodders. In addition to on-farm work, farmers have pursued more and more off-farm job opportunities. Other than income from agriculture and off-farm work, farmers may also receive income from government subsidy and other sources. The former covers monetary and in-kind compensations by the government, almost exclusively for land retirement/conversion and poverty alleviation under the SLCP. The latter constitutes minor gift, donation, and welfare items, if any, received from relatives, community, and public sources. In estimating incomes from both on- and off-farm sources, the unit labor cost is not included because of farmers' convention of excluding it from their net revenue calculation and the difficulty of determining it directly in a partially subsistent economy. Alternatively, the wage rate of labor in on- and off-farm employment can be computed as the quotient of net revenues divided by the corresponding work times. Similarly, the opportunity cost of cropland is its net revenue from grain production before it is enrolled in the program, approximated by the local average of farming net revenue. Because the government's subsidies were fixed without adjusting for inflation, we will use an annual discount rate of 4% in comparing them with farming revenues in the later years.
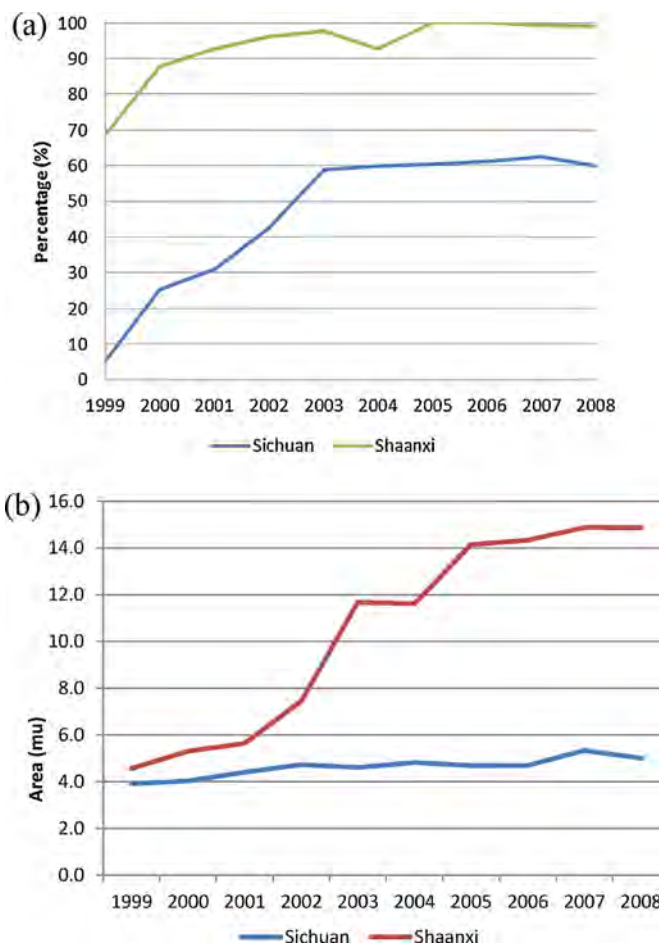
Fig. 2. Program participation during 1999–2008. (a) Percentage of sample households enrolled in the land set-aside. (b) Acreage of cropland enrolled in the land set-aside for each participating household.
Data source: Authors' surveys.

Descriptive results

Program participation

It can be seen from Fig. 2(a) that participation in the SLCP grew rapidly in the first three years, but stabilized thereafter. As mentioned, this was due to the high level of participation reached early on and the government's decision to scale back the set-aside target. An overwhelming majority of the sample households in Shaanxi were enrolled into the program immediately after it got underway, and virtually all participated by 2007. In Sichuan, only a small portion of the households got enrolled in the first two years and participation rose to roughly 62% of the households in 2006.

In terms of the amount of cropland retired, Fig. 2(b) indicates that Shaanxi started at a rate of 4.6 mu per participating family, and continued its rapid expansion and reached almost 15 mu in 2008. In Sichuan, cropland retirement began at a rate of 3.9 mu per participating family and gradually increased to around 5.0 mu. As a whole, though, farmers in Sichuan retired only 3.1 mu per household. The slight drop in retired cropland in 2008 was likely due to the exit of some families at the end of the first-round contracting. Varied rates of participating households and lands have to do with the availability of total and degraded cropland in a province. These variations also have to do with the aggressiveness of the provincial and local agencies in seeking out quotas for retirement and thus subsidies from the central government (Xu et al., 2006). Together, these factors explain why Shaanxi got much higher
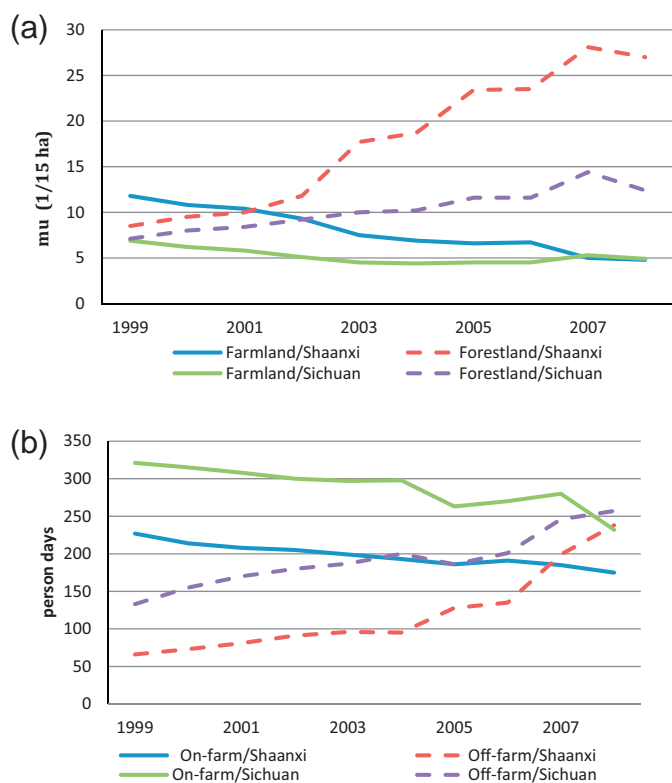
Fig. 3. Land and labor allocation dynamics. (a) Cropland and forestland dynamics for all sample households. (b) Labor allocation in agricultural and off-farm/off-village employment activities.

Data source: Authors' surveys.

levels of household and cropland enrollment and, ultimately, a higher level of compensation, as shown below.[4]

Land and labor allocation

It is anticipated that as a result of retiring and converting degraded cropland, the amount of remaining cropland decreases while forest and grassland increase. As detailed in Fig. 3(a), cropland per household in Shaanxi experienced a dramatic decline—from 11.8 mu in 1999 to only 4.8 mu in 2008. Meanwhile, forestland increased even more—from 8.5 mu to 27.0 mu. The contraction of cropland is smaller than the amount of land enrolled in the program due to the inclusion of non-permanent farming plots, or the gain in forestland due to tree planting and forestation elsewhere. In Sichuan, the overall cropland reduction from 6.9 mu to 4.9 mu is relatively moderate during the period, but the forestland increase from 7.1 mu to 12.4 mu was substantial. Thus, nonparticipating households held 6.4 mu of cropland and 9.3 mu of forestland in 2008, whereas participating ones held 4.0 mu of cropland and 14.4 mu of forestland.

In addition to the tremendous shifts in land allocation in the sample households, labor allocation changed a lot as well. Along with a marked decline in on-farm employment, a sharp increase in off-farm employment occurred simultaneously. Fig. 3(b) shows that family land-based labor time in Shaanxi reduced from 227 (person) days in 1999 to 175 days in 2008, whereas off-farm labor time grew from 66 days to 238 days, indicating that the share of off-farm work in total employment grew from 23% to 58% in a decade.

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[4] As such, it makes little sense to distinguish the program impacts between participating and nonparticipating households in Shaanxi in the following sections.

In Sichuan, the average family labor time in agriculture decreased from 321 days to 232 days, while off-farm labor time grew from 133 days to 246 days during the period. For all households in Sichuan, thus, the share of off-farm labor time grew from 29% to 53%. In comparison, non-participating households were able to maintain a higher level of employment in agricultural activities, while participating households were forced to seek a higher level of off-farm work (see Table 3).

It is also striking to notice that in the two provinces, the total household labor time increased markedly over time—41% in Shaanxi and 8% in Sichuan. This is because more and more surplus rural laborers were able to find off-farm job opportunities as the country's economy and urbanization continued their rapid-pace growths, or to create new and more profitable agricultural opportunities such as cash-crop and livestock production.

Agricultural production

The reduction of agricultural labor time and the increase of off-farm work should not inevitably lead to a proportionate decline in grain and livestock production, however, if the growth in agricultural productivity can sufficiently offset the negative effects induced by implementing the program. In practice, this can be accomplished, in large part, by intensifying production with more expenditure on purchasing modern farming inputs, such as improved seeds, fertilizers, pesticides, and plastic mulch; and better animal breeds, feeds, fodders, and disease-prevention services in livestock production (Yao et al., 2010). The local input use and production mode in agriculture have indeed been transformed. In Shaanxi, the household expenditure for agricultural production increased from 403 yuan in 1999 to 1187 yuan in 2008 (Table 4). Similarly, the family expenses for grain and livestock production in Sichuan increased from 660 yuan to almost 1200 yuan. Further, participating households in Sichuan had substantially higher cash outlays in farming and animal husbandry than non-participating ones, especially in 2007 and 2008.

These remarkable increases in production expenditure should have mitigated the declines in agricultural production and net revenue. Table 4 also reports that the family net revenue from farming in Shaanxi decreased from near 1400 yuan in 1999 to only about 600 yuan in 2008. In Sichuan, the same net revenue dropped from close to 1200 yuan in 1999 to just over 1000 yuan in 2008. But the net revenue from livestock production in the two provinces almost doubled. Its initial level was low in Shaanxi, only 435 yuan per household in 1999, and grew to 856 yuan in 2008. The gains in Sichuan were more impressive—from 1572 yuan to 3325 yuan. Also, the net revenue from livestock production in Shaanxi surpassed that from cropping by the end of the sampling period, whereas in Sichuan the former was always higher than the latter and their divergence grew larger over time.

Table 5 further disaggregates the net revenues from grain and livestock production in Sichuan into those for participating and nonparticipating households. Compared to participants, nonparticipants were able to maintain a slightly higher level of net revenue from grain production over time, but that from livestock production was much higher and the gap between the two groups enlarged over the last two years.

Structural change of income

As shown in Table 6, while income from agriculture as a whole increased, its pace of growth was much slower than that of off-farm income. In Shaanxi, household total income increased from 3849 yuan in 1999 to 9825 yuan in 2008. In Sichuan, it rose from 4951 yuan to 12,446 yuan. Therefore, household income in both provinces grew by more than 250%. Compared to a modest gain

Table 3
Participating status and labor allocation in agricultural and off-farm/off-village employment activities in Sichuan (unit: person days).

Year	Off-farm work time			On-farm work time		
	Participants	Nonparticipants	Difference	Participants	Nonparticipants	Difference
1999	183	130	53	345	319	26
2000	184	145	39	299	321	−22
2001	197	157	41	283	320	−37
2002	209	156	53	287	311	−24
2003	210	150	60	287	312	−25
2004	226	156	70	287	316	−30
2005	217	130	87	257	274	−16
2006	238	135	102	266	278	−12
2007	279	184	95	257	321	−65
2008	277	226	51	229	237	−8

Data source: Authors' surveys.

Table 4
Household expenditure and revenue in agricultural production (unit: yuan in 1994 constant price).

Year	Shaanxi			Sichuan		
	Expenditure	Net farming revenue	Net livestock revenue	Expenditure	Net farming revenue	Net livestock revenue
1999	402.8	1374.0	435.0	660.9	1198.4	1572.3
2000	387.5	1393.9	472.4	706.5	1202.5	1657.3
2001	381.5	1319.6	496.5	745.8	1198.0	1701.0
2002	372.4	1297.7	543.3	747.5	1225.8	1788.6
2003	375.1	1098.8	578.0	763.3	1271.9	1872.3
2004	341.0	1116.4	690.0	735.7	1317.6	2046.4
2005	405.9	1214.8	459.0	626.0	1073.6	1705.8
2006	433.8	1385.0	606.6	660.2	1143.4	1982.1
2007	946.2	1049.3	858.7	1316.7	1090.9	3455.8
2008	1186.5	604.3	885.5	1197.8	1011.0	3325.2

Data source: Authors' surveys.

of less than 480 yuan in agricultural income in Shaanxi, the off-farm income rose from 1108 yuan in 1999 to 4590 yuan in 2008. Likewise, household agricultural income in Sichuan increased from 3108 yuan in 1999 to 5317 yuan in 2008. At the same time, their off-farm income jumped from 1762 yuan to 6158 yuan. Overall, the share of agricultural income declined from 63% to 43% in Sichuan and only 29% in Shaanxi.

The remaining two income components in Table 6 fall in the categories of "Subsidy" and "Other." Due to their larger percentage of participation and greater amount of land enrollment, households in Shaanxi benefitted tremendously from participating in the SLCP. On average, a household there received an annual subsidy of up to 1929 yuan in 2006, accounting for 23.5% of its total income in that year. In contrast, Sichuan had a modest increase in both enrolled households and enrolled cropland. Even though households received 70 yuan/mu more subsidy per mu, they did not benefit as much as their counterparts in Shaanxi. The highest level of

Table 5
Disaggregated net revenues from grain and livestock production for the two different groups of households in Sichuan (unit: yuan in 1994 constant price).

Year	Grain production		Livestock production	
	Participants	Non-participants	Participants	Non-participants
1999	1141.2	1201.8	1197.6	1594.4
2000	1147.8	1222.7	1705.8	1639.5
2001	1128.7	1230.9	1653.6	1723.6
2002	1144.5	1294.5	1680.5	1880.0
2003	1239.1	1323.1	1801.2	1983.4
2004	1266.9	1402.8	1988.6	2143.5
2005	1051.1	1114.4	1603.7	1890.3
2006	1117.3	1191.3	1839.9	2243.1
2007	996.5	1264.0	3168.1	3983.1
2008	907.2	1180.6	3022.7	3819.6

Data source: Authors' surveys. Because of the almost universal enrollment in Shaanxi, no similar distinction can be made.

subsidy was 767 yuan in 2006, equivalent to 9% of the total household income in that year.

Table 7 illustrates the differences of total income and off-farm income between participating and nonparticipating households in Sichuan. The difference in total income fluctuated around 1000 yuan in favor of the participants, except for 2008. Part of the difference in total income is attributable to the higher income from off-farm sources for participants.

Income inequality

From the discussion of structural change and rapid growth of household income, we can imagine the substantial reduction of poverty and the improvement of livelihoods, which is consistent with what Chen and Ravallion (2007) reported. Nonetheless, it is worthwhile to look into the distributional change in household income and the SLCP's potential contribution to income inequality. As done by Li et al. (2011), we use the Gini coefficient as a measure of income inequality, which is calculated using the standard formula in the literature (see Eq. (8) of Pyatt et al., 1980). To obtain the sources of income inequality, we estimate the relative contributions of different income components to the Gini coefficient (based on Eq. (11) of Pyatt et al., 1980). By examining the variations of the Gini coefficient and its component parts over time, we will gain a sense of the dynamics of income inequality and its chief sources.

Table 8 shows that the Gini coefficient declined from 0.34 in 1999 to 0.28 in Shaanxi and 0.31 in Sichuan in 2005 first and then increased to 0.39 by 2008. These variations correspond to a slight decrease first and then a minor increase in income inequality in the sample counties. The table further reveals that most of the inequality is attributable to off-farm and agricultural income. The share of income inequality attributable to the SLCP subsidies was close to zero in Shaanxi, whereas its magnitude in Sichuan was less than 5.3%. This indicates that the subsidies received from participating

Table 6
The composition and structural change of house income over time (unit: yuan in 1994 constant price).

Year	Quantity					Percentage	
	Total	Agriculture	Off-farm	Subsidy	Other	Agriculture	Off-farm
Shaanxi							
1999	3848.0	2413.7	1108.3	326.0	0.0	0.63	0.29
2000	4375.6	2533.4	1320.9	521.3	0.0	0.58	0.30
2001	4501.7	2566.9	1426.7	508.1	0.0	0.57	0.32
2002	5187.8	2653.5	1714.6	819.8	0.0	0.51	0.33
2003	5400.5	2458.7	1739.8	1201.9	0.0	0.46	0.32
2004	6091.3	2688.0	1863.7	1539.5	0.0	0.44	0.31
2005	7290.6	2388.5	2764.4	1854.1	283.6	0.33	0.38
2006	8205.9	2819.3	3163.5	1928.8	294.3	0.34	0.39
2007	9294.7	3130.5	4178.6	1493.8	491.9	0.34	0.45
2008	9825.4	2880.7	4589.9	1783.6	571.2	0.29	0.47
Sichuan							
1999	4951.2	3108.2	1762.4	80.5	0.0	0.63	0.36
2000	5580.3	3217.5	2111.0	251.8	0.0	0.58	0.38
2001	5948.2	3286.7	2380.0	281.5	0.0	0.55	0.40
2002	6591.0	3439.6	2747.9	403.5	0.0	0.52	0.42
2003	7196.1	3616.9	3053.4	525.8	0.0	0.50	0.42
2004	7709.0	3881.8	3261.4	565.8	0.0	0.50	0.42
2005	7570.0	3427.4	3163.3	723.4	255.9	0.45	0.42
2006	8540.3	3847.2	3651.6	767.0	274.4	0.45	0.43
2007	11571.5	5070.5	5616.2	594.8	290.0	0.44	0.49
2008	12445.6	5316.8	6157.8	554.4	416.6	0.43	0.49

Data source: Authors' surveys. "Subsidy" primarily comes from cropland retirement and farming; "Other" means local welfare compensation and assistance to the poor and disabled.

in the SLCP caused little income inequality. In other words, the poor and not-so-poor households benefitted almost equally from it.

Attractiveness of the subsidy

To scrutinize issues related to the adequacy and appropriateness of government subsidies, we approximated participants' net revenue from grain production with the average value of all the sample households in each sample county. Fig. 4 indicates that the average net revenue from farming generally below the government subsidies. The figure is based on the sample county with the highest net farming revenue in a province and that this approximation also could be biased upwards because the retired plots of cropland tend to be the marginal ones with low yields. This proves that if they were fully delivered to participants, the government nominal subsidies for restoring cropland during the initial round—230 yuan/mu a year in Sichuan and 160 yuan/mu a year in Shaanxi—were very generous and overcompensation has happened in most of the years. Put differently, the overcompensation may be seen as a measure of poverty reduction, as articulated in the initial

Table 7
Total and off-farm incomes for the two different groups of households in Sichuan (unit: yuan in 1994 constant price).

Year	Total income		Off-farm income	
	Participants	Non-participants	Participants	Non-participants
1999	5124.9	4940.9	2107.9	1742.1
2000	6334.0	5302.1	2397.4	2005.3
2001	6541.8	5666.2	2647.8	2252.8
2002	7050.6	6202.2	3078.7	2468.2
2003	7525.1	6682.6	3266.3	2721.0
2004	8136.2	6991.6	3580.1	2726.1
2005	7890.9	6990.5	3720.8	2874.5
2006	8907.6	7866.2	4294.6	3249.5
2007	11654.9	11418.8	6124.9	5505.4
2008	12127.3	12965.8	6555.1	6606.0

Data source: Authors' surveys. Because of the almost universal enrollment in Shaanxi, no similar distinction can be made.

Fig. 4. Comparisons of the subsidies with farming revenues (unit: yuan/mu in 1994 constant price).
Data source: Authors' surveys as well as the stipulated governmental subsidies. The net farming revenue was estimated as a proxy for the opportunity costs of retiring cropland. The two counties were chosen because they had relatively higher net revenues from farming. Since the nominal subsidies were fixed, an annual discount rate of 4% was taken in comparing with the net revenues from farming.

program document (SFA, 2003).[5] If so, the poverty reduction benefit for participating households can be easily computed—ranging from 82 to 100 yuan/mu in Shaanxi and 118–136 yuan/mu in Sichuan during the first three years. Also, we do see a gap in the net farming revenue between the Yangtze and Yellow River basins in most of the years.

Likelihood of reconversion

One way to discern the likelihood of reconverting retired cropland back to cropping when the contract expires is to compare the wage rates for agricultural production and off-farm employment.

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[5] China's official poverty line—an annual income of 637 yuan per person—was set in 1994 and lasted until 2007, when it was raised to 785 yuan (National Statistics Bureau, 2010).

Table 8
Estimated Gini coefficients and their sources.

Year	Gini coefficient	Sources (%)			
		Land-based income	Off-farm income	Subsidy and other income	Total
Shaanxi					
1999	0.34	14.35	84.45	1.21	100.00
2000	0.34	18.39	80.64	0.97	100.00
2001	0.34	52.07	47.93	0.00	100.00
2002	0.34	46.03	53.97	0.00	100.00
2003	0.34	48.02	51.98	0.00	100.00
2004	0.34	47.46	52.44	0.10	100.00
2005	0.28	37.92	62.08	0.01	100.00
2006	0.29	41.62	58.36	0.02	100.00
2007	0.33	36.69	63.17	0.14	100.00
2008	0.39	43.62	51.40	4.98	100.00
Sichuan					
1999	0.34	36.45	62.06	1.49	100.00
2000	0.34	30.32	64.74	4.94	100.00
2001	0.35	27.84	68.18	3.98	100.00
2002	0.33	25.55	70.20	4.25	100.00
2003	0.33	24.79	71.57	3.64	100.00
2004	0.33	26.58	69.67	3.75	100.00
2005	0.31	11.39	83.36	5.26	100.00
2006	0.31	11.61	83.37	5.02	100.00
2007	0.37	20.83	77.07	2.10	100.00
2008	0.39	27.74	70.96	1.29	100.00

Data source: Authors' surveys. Here "Subsidy" and "Other" incomes are lumped because the latter is very small, if not zero.

As illustrated in Fig. 5, the wage rates of participating households from off-farm opportunities are universally higher than those from agriculture for the last three years of our data coverage (2006–2008). It can thus be inferred that if rural laborers can make higher earnings from off-farm activities than from those on-farm ones and if the recent trend of rural labor transfer can continue, it seems less likely that rational farmers will return to farming.

Econometric findings

While the above observed changes are hugely beneficial to understanding various facets of the program implementation and impacts, the results may not be definitive or conclusive without being carefully tested with an appropriate econometric approach. Here, we present our findings from a multivariate regression analysis. Before proceeding, though, it is helpful to outline our modeling strategy first. Based on what has been observed, we posit that household income and employment are determined by production inputs, program participation, and/or other control variables including family and village characteristics as well as regional dummies to capture potential spatial heterogeneity. Specifically, we hypothesize that: (1) households' incomes from different sources have been affected by their statuses of participating in the SLCP, but

the effects on different categories of income may not be the same; (2) the increase in off-farm employment has also been impacted by the participation statuses; and (3) changes in income and employment are conditional upon the influences of other variables as well.

Included in our independent variables are production inputs—expenses for land-based production, labor time for land-based production, labor time for off-farm employment, and the amounts of farmland and forestland; household and village characteristics—family size; age, years of schooling and status of village leadership for the household head; road condition (whether there is a paved road); and distance from a village to its nearest township. As a typical procedure, all but the dummy variables were transformed logarithmically for better fitting and easier coefficient interpretation (as elasticity). To alleviate any concern about the attrition and fluctuation of the sample size, we decided to use a balanced panel in our estimation (by removing those households without observations throughout the ten years), in conjunction with a household-level, fixed-effects estimator. We also tested the possible existence of endogenous program enrollment and thus off-farm labor time (Wooldridge, 2002), but we found no self-selection in either case. This is not surprising in view of the fact that once an area was designated by the local government for retirement, the window of opportunity for households to enroll was brief, and participation might not be fully voluntary (Yin et al., 2010); off-farm work could have more to do with the push for program participation and the pull from the economic growth and urbanization. Therefore, the chances for endogenous selection seem limited. Our estimated results are summarized in Table 9.

First of all, the contributions of the SLCP to farm, off-farm, and total income are all significantly positive, suggesting that a larger program enrollment leading to a greater family income. Obviously, its primary impact comes from triggering more off-farm work, resulting in larger income gains. In comparison, program participation has a very small, albeit significant, effect on farm income. Further, our analysis shows that among all the production inputs, land-based expenditure has a large positive impact on farm income; because its effect on off-farm work and income was negative, its impact on total income is very small. In contrast, farming labor time has a modest, positive effect on farm income, but it is negatively correlated with off-farm income. In combination,
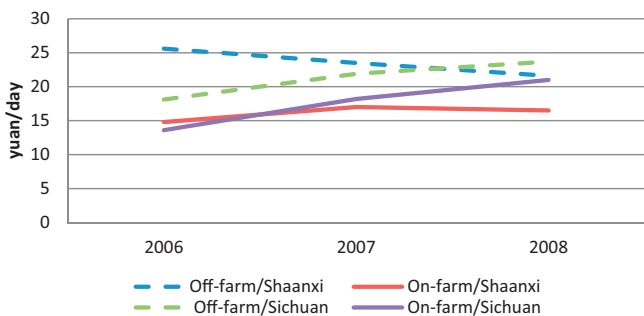
Fig. 5. Estimated wage rates of different jobs for participants (unit: yuan/mu in 1994 constant price).
Data source: Authors' surveys.

Table 9
Estimated coefficients of income and employment regressions.

Independent variable	Dependent variable			
	Total income	Land-based income	Off-farm income	Off-farm Labor
Area enrolled in SLCP	0.029***	0.050***	0.095***	0.172***
	(0.001)	(0.003)	(0.012)	(0.013)
Land-based production expenses	0.004**	0.149***	−0.035*	−0.068***
	(0.002)	(0.004)	(0.020)	(0.018)
Farming labor days	−0.004*	0.146***	−0.160***	
	(0.002)	(0.005)	(0.025)	
Off-farm labor days	0.026***	−0.009***	0.649***	
	(0.001)	(0.002)	(0.008)	
Farmland area	0.007***	0.017***	0.076***	−0.028
	(0.002)	(0.004)	(0.019)	(0.021)
Forestland area	0.014***	0.015***	0.036**	0.031*
	(0.001)	(0.003)	(0.015)	(0.012)
Road condition (dummy)	0.165***	0.025	1.458***	0.069
	(0.018)	(0.039)	(0.199)	(0.218)
Distance to township	−0.028***	0.011	0.481***	0.392***
	(0.007)	(0.014)	(0.075)	(0.084)
Family size	0.456***	0.429***	0.770***	3.631***
	(0.020)	(0.045)	(0.231)	(0.252)
Household head education	0.012***	−0.003	0.099***	0.065***
	(0.002)	(0.004)	(0.019)	(0.021)
Household head age	1.159***	0.402***	6.507***	3.171***
	(0.033)	(0.068)	(0.368)	(0.411)
Household head leadership (dummy)	0.066**	0.243***	1.326***	−0.203
	(0.033)	(0.070)	(0.376)	(0.418)
Constant	3.960***	4.379***	−24.588***	−17.607***
	(0.127)	(0.269)	(1.428)	(1.579)
R^2	0.230	0.357	0.443	0.034

Note: The coefficients were obtained based on a household-level, fixed-effects estimator; the panel, which was balanced to avoid any concern over the effect of attrition and fluctuation in annual observations over time, contained 10,650 observations; rounding was made in reporting the regression results.

  * Significance at 90% level.
  ** Significance at 95% level.
  *** Significance at 99% level.

the net effect on total income is small and negative. On the other hand, off-farm labor time has a large positive impact on off-farm and total income, but its effect on farm income is slightly negative. Further, while farmland is positively correlated with farm and off-farm income, the overall effect is small. An expansion in forestland results in a gain in land-based income and also triggers an increase in off-farm work and thus income; however, the coefficients are not large.

As to the influences of household and village characteristics, we find that access to a paved road benefits both on-farm and off-farm income, leading to a positive effect on total income. On the other hand, even though being more remote from the local commercial center—township—can lead to more off-farm work, its overall impact on income is slightly negative. Moreover, larger families tend to undertake more on-farm and off-farm work and therefore to increase both categories of income. More years of schooling of the house head is correlated with an increase in off-farm income and total income, whereas age of the house head has a positive correlation with every category of income. Also, if the house head is a village leader, family income in every category tend to be a bit higher, suggesting that the information and opportunity sets facing a village leader may be more advantageous than otherwise.

In short, our regression results have nicely confirmed and indeed complemented what we observed from our earlier descriptive analysis. Participating in the SLCP triggered increased work in and income from off-farm activities; and it also positively affected farm income by stimulating a structural adjustment of land-based production activities. Moreover, the observed income and employment changes are influenced by production inputs and other control variables, such as household and village features. Overall, among other things, farming expenditure, off-farm labor time, amounts of farmland and forestland, road condition, and family size are positively correlated with family total income. In contrast,

on-farm labor time and distance from nearest township are negatively correlated with total income.

Discussion

This study was motivated primarily by our desire to present a clear and concrete depiction of the SLCP—China's largest PES program, so that the basic facts concerning its implementation and impacts can be established, while challenges facing policymakers and practitioners can be better understood and the research needs better identified. We have done so by examining the induced changes in program enrollment, land and labor allocation, agricultural production and revenue, and structural change of family income. From this detailed analysis, we can draw a number of observations and inferences pertinent to improved policy execution and assessment.

It is found that at least in the short run, the SLCP has been very successful in achieving its goals of ecological restoration, income enhancement, and poverty alleviation. As impressive as these changes may suggest, however, we must guard against any overoptimism about its long-term success, because retiring degraded croplands is only the initial step of restoring them. At the present, little is known about: (a) how the survival and growth rates of the recovered trees or vegetation are; (b) how the ecosystems function differently, with various degrees of restored vegetation and trees; and (c) whether the desired ecosystem services, such as erosion control and biodiversity protection, have been markedly improved. Our field work indicates that while trees were planted and vegetation was established on the set-aside sites, there has been a striking lack of follow-up tending, such as competition control, supplanting, and thinning (Yin and Yin, 2010). It is thus crucial to recognize that restoring degraded ecosystems is a long and arduous process that requires sustained efforts of maintenance and management, to

which adequate attention must be devoted (Yin et al., 2013). Also, the success of any restoration program must be ultimately assessed against the improved provision of ecosystems services (Daily and Matson, 2008). To that end, the current local governance needs to be strengthened, particularly in terms of active local participation in management and monitoring, and careful alignment with local interests (Agrawal et al., 2008; Xu et al., 2006).

Moreover, implementing the SLCP has coincided with the unprecedented socioeconomic transition in rural China, as manifested by the remarkable shifts in land use, employment opportunities, and income composition. Hence, it is important to ascertain to what extent the socioeconomic changes can be attributed to implementing the program or to the socioeconomic transition (Grosjean and Kontoleon, 2009; Groom et al., 2010). Past studies have largely ignored this broader context in their analyses of the induced effects of the program on labor use, production change, and income growth, which could have generated biased findings as well as inappropriate policy prescriptions (Yin et al., 2010). From the government's viewpoint, a key step is to direct more efforts to the transfer of rural labor and the structural adjustment of production by promoting technical training, improved credit availability, and information services for new employment opportunities, such that the momentum of rural development will continue and the human pressures on ecosystems can be further mitigated (Yin, 2009; Uchida et al., 2009). It is especially useful to sort out how to alleviate the hardships that the local people may suffer and to enhance their resilience and capability in this transitioning process (Xu et al., 2006; Cao et al., 2009). That being the case, it seems that the likelihood of reconverting the set-aside cropland back to farming is small, unlike what has been suggested in some of the previous studies.[6] This is because of the profound impacts on wages and earnings as well as on reducing the necessity of generating a bulk of the family income from land-based activities, resulting from transferring on-farm labor into off-farm, off-village sectors.

However, it should be pointed out that the incentive structure in rural China has already been altered more recently by the reduction in the land retirement and conversion compensations and the increase in subsidies for grain and livestock production (Ministry of Agriculture, 2011). Consequently, the relative attractiveness of keeping cropland in retirement has been diminished. More work is thus called for to detect how a coherent incentive system can be maintained and regulations enhanced in solidifying the restoration achievements and promoting more sustainable land use and poverty reduction (Yin and Zhao, 2012). In this regard, it is worthwhile to examine alternative schemes of program design in accomplishing ecological restoration and economic development, including further poverty reduction (Tallis et al., 2008; Sachs and Reid, 2006).

Additionally, even with the remarkable aggregate changes, it must be recognized that certain households have not been much engaged in off-farm activities and have continued their dependence on farming for their livelihoods. And even if their family income is above the official poverty line, many of them remain in a precarious status and do not enjoy a decent life in terms of the international standard of "$1 a day" (Chen and Ravallion, 2007), for instance. Therefore, it is more likely that these less fortunate and relatively poor households will reconvert some of the set-aside cropland back to farming (Yin et al., 2013). Efforts must be made to target these disadvantaged households to avoid any potential reconversion of the retired cropland and to make sure that the generous subsidies have been fully delivered to the program participants. Further, since

large variations exist in local conditions as well as the extent of participating in the land retirement program, it is hard to reach more generalizations regarding the program impacts despite the temptation to do so.

The diverse situations and local specificities call for caution when an analyst uses highly aggregated data and makes sweeping statements about the program performance; conversely, the same questions in different parts of the country should be examined in separate case studies (Yin et al., 2010). Our results also demonstrate that the actual and assessed impacts vary with the lengths of time and the locations and variables that the data cover. In this sense, it is not surprising to see divergent outcomes in the previous studies. It is thus beneficial to conduct disaggregate analysis before scaling up; and it is in this process that an analyst must be aware of the roles that program extent, local economy, and political leadership play in influencing off-farm employment and income generation (Yao et al., 2010). Likewise, financial and technical support to land and labor allocation can alter their opportunity costs, and eventually the incentives for farmers to participate and the likelihood of their reconversion of retired cropland. With concurrent shifts in land and labor uses, the idea of linking land use and labor allocation choices explicitly is appealing for studying the behavior of rural households as these choices are likely correlated (Grosjean and Kontoleon, 2009). Finally, if possible, analysts should strive for more comprehensive data, with broader spatial, longer temporal, and more complete coverage, in order to reach robust empirical findings.

The above discussion also makes it clear that the subsidy standards should be localized to reflect the variability of biophysical and socioeconomic conditions. The current stipulation of broadly uniform subsidies raises people's concern about the efficiency and equity of the program (Yin and Yin, 2010; Xu et al., 2006; Bennett, 2008). This is because a uniform standard inevitably leads to places with lower grain yields and thus lower opportunity costs of retiring cropland to benefit more while others with higher yields to benefit less or even suffer a net loss. Similarly, the efficiency of the program implementation can and should be improved, given the apparent overcompensation and the financial need for retiring more marginal lands and retaining those retired. To enhance the cost effectiveness, the current system may be replaced by payments made according to the potential environmental benefits as well as the opportunity costs of local conditions (Wunder et al., 2008; Yin et al., 2013). It is also essential to adjust the subsidies to reflect inflation so that the attractiveness of cropland retirement can be better maintained.

Another issue that has not been well explored is the induced agricultural productivity change. Clearly, if farming has been adversely impacted, it will have undesirable consequences on food security, income generation, and economic viability, which will in turn call into question the sustainability of the program. Otherwise, if implementing it has enhanced productivity by combining technical efficiency, scale economy, and/or technological change, the supply of grain and other farm products will come from ore intensive use of the reduced land base (Godfray et al., 2011; Yao and Li, 2010). So, the intention of the program may be validated—environmental improvement and economic growth can be accomplished simultaneously.

Conclusions

The SLCP has substantially and positively affected the land and labor use in western China, by simultaneously retiring degraded cropland and increasing forest and vegetation covers. These dynamics accelerated the transfer of farm labor into off-farm and/or off-village sectors. Farm labor work decreased from over 60% of the

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[6] For instance, Cao (2011) reported that 37.2% of the participants in Shaanxi, 34% percent in Guizhou, and 29% percent in Ningxia indicated their intention to return to their retired plots to farming as soon as the subsidies expire.

total labor time to no more than 43%, while off-farm labor time increased to more than a half of the total in the sample counties. Meanwhile, rural households intensified agriculture by increasing their expenditures on grain and livestock production, enabling them to offset some of the negative effects of the large-scale cropland set-aside and reduced on-farm labor use. Our evidence suggests that even in the case of near-complete program participation in Shaanxi, grain production did not suffer a proportionate decline and livestock expanded.

Collectively, these developments led to the modest increase of income from agriculture. For the participating households, another significant source of their income increase was the direct subsidies by the government. For both participating and non-participating households, however, a much larger portion of their income gain came from an increase in non-farming jobs. Related to these major shifts is the large increase of total household labor use over time, driven by the tremendous rates of economic growth and urbanization. As a result, the total household income increased by more than 250% by 2008, whereas implementing the SLCP caused little income inequality. Accordingly, rural poverty and thus the most vulnerable population have been substantially reduced, and the rural livelihoods much improved.

Lastly, China's SLCP experience shows that restoring degraded ecosystems is a complex process that entails allocating a large amount of public financial resources by the authorities to subsidize the adoption of a series of restoration actions by millions of farmers over an extended period of time. For any serious attempt to promote its long-term success and evaluate its performance, an adequate understanding of the fundamental elements of its impacts as well as its challenges is essential (Yin et al., 2014). Likewise, for those interested in the design and execution of large PES projects or ecological restoration programs in improving ecosystem services and human well-being, China's SLCP offers a number of valuable lessons to be learned. We hope that this study has contributed to those endeavors.

Acknowledgements

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Factors affecting farmers' participation in China's group guarantee lending program

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Abstract

Purpose – Based on a survey of 897 farm households, the purpose of this paper is to build a framework using cluster analysis to explain how farmers make decisions on joining group guarantee, and analyzes factors influencing their decisions using multinomial and binary Logit regressions.

Design/methodology/approach – The approach of combining cluster analysis with Logit regression is an innovative approach to survey assessment. In addition, by design the authors have identified the four mutually exclusive groups of borrowers combining Group Guarantee membership and actual formal borrowing.

Findings – An extremely important observation according to the data is that most farmers appear to be part of group guarantees only because they have to in order to get access to formal credit products. 87.21 percent of the people who belong to groups and utilize the formal credit products belong to this category because their lenders have made participation in groups compulsory for access to credit. This may ration farmers' willingness to even apply for credit. It also indicates a preference on the part of older and more risk-averse respondents to avoid participation in group guarantees. Out of financial characteristics the total loan holdings appears to be the only significant indicator of participation in group guarantees. Furthermore the results indicate that informal and formal credit appear to be replaceable for farmers.

Research limitations/implications – The survey is confined only to the counties investigated. China is very diverse in its agricultural economies and many RCCs operate under different guidance and rules from those investigated here. Hence, while the authors can claim that the results are indicative, the authors cannot claim that they will hold generally.

Practical implications – Based on group guarantee loan mechanism and survey data analysis of 897 farm households, this paper analyzes influencing factors affecting farmers' participation in group guarantees from microcosmic level, so as to provide some reference to further perfect micro credit operation mode and mechanism.

Social implications – The results indicate that the Group Guarantee mechanism, while beneficial to some, may not hold global appeal for Chinese farmers. In the future RCCs may want to consider alternative approaches to loan security than placing the burden of guarantee on farmers' family and friends.

Originality/value – The approach of combining cluster analysis with Logit regression is an innovative approach to survey assessment. In addition, by design the authors have identified the four mutually exclusive groups of borrowers combining Group Guarantee membership and actual formal borrowing.

Keywords China, Agricultural finance, Group guarantee

Paper type Research paper

1. Introduction

In recent years the Chinese government through policy directives from the Peoples Bank of China and the regulatory oversight from the China Banking Regulatory Commission has taken specific policy actions to increase credit to farmers. Since 1983 a program of micro credit has been in place through Rural Credit Cooperatives and other formal lenders. In addition new policies have given rise to an expanded role for Postal Saving Banks, licensing of Village Banks, conversion of RCCs to Rural Credit Banks using external equity, lending only companies and micro finance institutes. At the same time guidance toward the implementation of group guarantees and credit worthiness was implemented. Shen *et al.* (2010) discuss the historical role of group guarantees for town and village enterprises and illustrate how the role of group guarantees has historically influenced rural investment, and also the consequences of removing the guarantee structure. Reconstituting the group guarantee as the backbone for micro credit loans, however is new and needs to be investigated. Research by Chinese scholars has shown that micro credit has played an important role in the process of helping farmers escape poverty and increase wealth (Nie, 2010). In recent years, micro credit capital has exceeded 8 billion RMB for 1.7 million households every year averagely (Huang *et al.*, 2009). Group guarantees have been attributed to the success of many micro credit projects (Zhang, 2009) which in many instances have proven to be an effective approach to poverty alleviation and financial development (Jin *et al.*, 2008).

Despite optimism about group guarantees we are unaware of any studies that have investigated what farmers actually think about group guarantees, their willingness to borrow with guarantors, their willingness to act as a guarantor and so on. These are important questions; 1.7 million farm households have benefited from guarantee loans in progress, but this is a fraction of the 250-300 million farm households that make up China's agricultural economy. Feng (2006) has argued that the group guarantee mechanism has many defects, such as loans cannot satisfy farmers' effective demand, loan terms are not reasonable, the loan procedure is complex, financial institutions have difficulties in monitoring loans and face communication obstacles; in addition, the group guarantee mechanism may still exclude the poorest households (Tang, 2008), and lacks clarity in policy and guidance and management oversight (Fu, 2008). Potential risks, arise because of systemic risks faced by all group members (Wu, 2009).

The number of farm households in a group guarantee as either borrower or guarantor appears in our sample to be very small. One observation, is the possibility that as well intentioned the group guarantee system is in China, it may have an unintended consequence of further rationing farmers from the market. The economic underpinnings of joint liability are discussed in detail below and one of the discussion points is the notion that a guarantee system reduces adverse selection and moral hazard through peer selection and peer monitoring. But for this to occur, high risk farmers must identify other high risk farmers that they trust, while low risk farmers must identify low risk farmers that they trust. Since the social network in Chinese villages is so strong, farmers know other farmers, with intimate detail and this may in

fact be inhibitive. Familial lending as discussed in Turvey and Kong (2010) and Turvey *et al.* (2010) is far more popular than formal lending. While there is a historical context to lending among friends, that this has not subsided in the presence of credit reforms leaves one to wonder as to why. Peer selection may be more intrusive than theory would dictate; high risk types would never enter into a joint guarantee contract, leaving in essence only low risk types to borrow under the guarantee system and of this group only those that can actually match up with other low risk types will actually benefit. This cannot easily be attributed to explicit or purposeful rationing by the lenders themselves, but as an unintended consequence of the policy itself. This is what we mean by "policy rationing."

2. Group guarantees
The emergence of group guarantees along with the expansion of micro credit loans to agriculture, rural communities, and farmers (referred to as Sannong – the three agricultures) was in response to problems affecting asymmetric information that universally affects access to credit in developing regions including (but not entirely limited to) high rates of default, high correlations among default, and the high costs of screening loan applicants and pursuing delinquent borrowers (Stiglitz, 1990). The pursuit of delinquencies is more exacerbated in countries like China in which farm households do not hold collateral rights to the land they farm and in many instances have few assets that could qualify as collateral, or that farmers would be willing to use as collateral. The consequence of these asymmetries is that traditional lenders shun rural households by avoiding to establish branches in villages, rationing the amount of loans made available to households, or price rationing potential borrowers along their individual credit demand curves by charging high interest rates

The contextual base of Stiglitz's (1990) argument was the coexistence of usurious rates of interest offered by money lenders in rural areas and the observation that money lenders and formal lenders could coexist in a seemingly complementary manner. Although there is scant evidence that money lenders operate on a wide scale in rural China (Turvey and Kong, 2010), Stiglitz argued that thriving pockets of money lenders elsewhere arose because of peer effect; that is money lenders had more local information about farm households than that could possibly be gathered by formal lenders. Turvey and Kong (2010) make a similar argument in the Chinese context with respect to familial lending between friends and relatives at zero interest with familial lending being sustained beyond the outlawing of usurious lending because of trust, guilt, and reciprocity. These peer effects, they argue, not only crowd out micro finance (of the Grameen type) but compete directly with credit from formal lenders (including Rural Credit Cooperatives).

Although Stiglitz (1990) used money lenders to illustrate the strength of peer monitoring in rural credit marketing, his real objective was to examine the effects of peer monitoring on group lending activities. Group lending in his context was of the Grameen type in which loans are made to self-formed groups of farmers who are mutually responsible for paying the loans, and whose members cannot obtain further loans until the previous loan was repaid in full. The empirical research results of Pitt and Pickering (1996) showed that the group guarantee loans from the Grameen Bank in Bangladesh contributed to household income increase s of 29 percent, total value of agricultural and non-farm products increases of 56 percent, labor force participation and months working hours increases of 7 percent, and agricultural wage increases of 5 percent. In addition, absolute poverty degrees of villages participating in group guarantee loans declined 75 percent (relative to villages not participating). Hollis and

Sweetman (1998) analyzed group guarantees from the macroscopic level, and they found that group guarantee loans had a macro influence on the whole development of financial markets, especially since it promoted growth and development.

At this point we need to make a distinction between group lending activities with mutual responsibility and group guarantees in the Chinese context. In China a group guarantee is one in which a single borrower will request three to five associates (friends or relatives) to provide guarantees on that loan. The loan is made to the principle borrower, with no obligation by the guarantor to also borrow, or any obligation by the lender to provide a loan with any favorable terms to the guarantor. In other words, while Grameen-style group lending ties borrowing activities to guarantees, the Chinese system of group guarantees is not a tied program and has no such linkage.

Nevertheless, the peer influence in China's group guarantee system cannot be overlooked and to our knowledge the peer effects and other models explaining mutual guarantees has almost entirely been focussed on group lending activities which have not been considered in the rise of group guarantees in China. Stiglitz makes the case that additional borrowing capacity is a sufficient incentive to ensure that mutual guarantees work but logistically group borrowers can also monitor other borrower behavior and can intervene if one member was taking undue risks relative to the group. In fact self-selection of group members would organize around member risks. Group risks among negatively correlated member risks may be sustainable from a portfolio risk point of view since bad turns by one group of borrowers can be offset by good turns among the remaining members. But this would have to be strategic so that negatively correlated risk would evolve in time so that no one group is burdened unfairly with a net subsidy transfer. Independent risks, would provide no a priori subsidy to one group or another, while group membership with positively correlated (systemic) risks would require that as a group buffer savings in good years would have to be set aside to offset shortfalls in bad years. Even so there would be a natural inclination for groups to ultimately self-select among members with nearly perfectly correlated risks since peer monitoring of deviations from common risks would be more symmetric and easier to monitor than the alternatives.

The group guarantee system in China is not much different. As indicated, becoming a member does not obligate the guarantor or lender to any contemporaneous borrowing or lending activities and this is the key difference to group lending. On the other hand this difference may not be so great if reciprocity is considered. Under a reciprocal arrangement a guarantor may willingly guarantee a loan if it is understood that provision of the guarantee today increases the potential pool of guarantors if needed for a future loan. This provides a double incentive; first it is in the guarantor's best interest to monitor the activities of the borrower to ensure that the loan is paid so that the guarantor does not lose on default, and secondly a borrower with bad credit risk will not be approved as a guarantor by the lending institution. This is essentially equivalent to the incentives described by Varian (1990) in an agent monitoring scheme to route hidden actions.

Actually the Group Guarantee program, at least at the time that this survey took place was part of guidance by the CBRC and it was up to individual RCCU at the provincial or county levels to decide whether the group guarantee will be used. In our experience we have found local managers requiring a group guarantee for any loan, group guarantees for loans above 30,000 RMB, and others refusing to require group guarantees until "guidance" became a "regulation." Note that in our regression analysis we actually include a dummy variable to capture whether the local RCC required the group guarantee rather than just requesting a group guarantee or not requiring it at all.

In general, the group guarantee depends on the credit worthiness of the borrower. In some areas of Shaanxi, for example, the local RCC worked with village leaders to identify credit worthy households and after doing so offered loan to the farmer unsolicited. Yet another RCC would evaluate credit worthiness only at the time a loan was made. In yet other jurisdictions entire villages are labeled as being credit worthy opening up loan facilities for all villagers. Again it is up to the local RCC to determine whether a group guarantee is required. Just because a farmer is identified as being credit worthy does not necessarily imply that a group guarantee is not required.

The substitutability of collateral for interest rates as discussed by Bester also consigns insights into group guarantees if the value of those guarantees to the lender is of substantial strength as to substitute for collateral. This is discussed in Ghatak (1999, 2000) who argues that preservation of collateral or collateral-free lending can arise if the incentives of group guarantees are correctly put into place. Thus borrowers vested in group guarantee risk collateral as a last resort rather than as the principal means of collecting on non-accrual loans. In the Chinese context there are additional costs to identify group guarantors, but this may be worth it. Ghatak (2000) and Van Tassel (1999) argue that self-selecting guarantors provide an informational advantage to the lenders. A low risk farmer would be foolish to guarantee a loan for a high risk farmer so it is reasonable to assume that high risk guarantors are required for high risk producers and low risk guarantors for low risk farmers. But it is unlikely that high risk guarantors would burden their own high risk activities by guaranteeing the loans of a high risk borrower. Tang (2008) discusses this issue with Chinese group guarantees. In theory, at least, the screening provided by the group guarantee should reduce adverse selection and hidden information, reduce moral hazard, and increase credit access to safe borrowers (Hermes, 2005).

The group guarantee mechanism naturally requires some strength in social capital. Using experimental techniques across multiple countries for group lending activities, Cassar and Wydick (2008) find that it does matter and is stronger when groups self-select. But there are cultural differences, including religiosity, that matter. Trust is significant. Of course there is no group lending activities in China, but it is the strength of group dynamics that we are interested here. One particularly interesting result was in a monitoring system. If group members could observe the action of others then in many instances the defection of one group member would spiral into a defection by all group members. In a counter-treatment defections were much lower in the absence of information. It is unclear whether participants were allowed to communicate moral persuasive arguments to prevent defections, but the point is clear that even among group members joint liability does not ensure a desirable outcome in the absence of more stringent incentives (see also Mude, 2006). We are aware of several instances in China where the group guarantee mechanism broke down. The other aspect is trust. In a moneyed experiment conducted at one USA university and two Chinese universities to examine whether the poor are more trustworthy than the rich, Kropp *et al.* (2009) find evidence, not strong though, that the conjecture may be true. Chinese students repaid at rates so high that a wealth effect could not be measured, but the lower repayment of (individual) loans by USA students did show that students who believed they were poorer than average repaid at higher rates.

In the existing literature, scholars have more systematic evaluations and arguments about guarantee mechanism, application effect and existing problems, and less empirical analysis about the formation mechanism from micro level. Based on survey data analysis of 897 farm households in Shaanxi and Gansu gathered in 2009, this paper analyzes influencing factors affecting farmers' participation in group guarantees from a

microcosmic level, so as to provide some reference to further perfect micro credit operation mode and mechanism in China.

3. Data and methods

In this paper we use a rather unique methodology to investigate group guarantees. In our field survey we constructed a series of questions to properly identify membership of those that borrow formally and are in a group guarantee, borrow formally but are not part of a group guarantee, do not borrow formally and are part of a group guarantee, and do not borrow formally and are not part of a group guarantee. Identification along these four lines of inquiry are important because in the first two the respondent is likely asking others to provide a guarantee while in the second two the respondent is likely being asked by other borrowers to provide a guarantee. We do not believe simply asking whether a respondent is a member or not provides sufficient detail so that additional instruments are required. Nor do we believe that participations decisions should be characterized by simple representations of attitudinal factors.

Instead we combine cluster analysis with regression analysis. The clusters were created using SPSS's two-step clustering technique. This technique is a type of hierarchal agglomerative clustering technique. The procedure is referred to as two-step because it combines the Bayesian Information Criterion along with Hierarchal Clustering. The log-likelihood distance was used to formulate the clusters. Clusters allow for exploratory analysis when there is not much known about groupings that might exist in the data, which is why it was an appropriate technique for this paper. Using two-step cluster analysis we define three sets of clusters along three dimensions. The first clusters are obtained from attitudinal questions about group guarantees; the second clusters define groupings of common attitudes toward risk; and the third cluster grouping examines social networking and attitudes toward peers. We find four, two and three clusters for each of the three groupings, respectively. By construction, each set of clusters captures common (highly correlated) factors within each cluster while maximizing the distance (independence) between clusters. Thus a set of n attitudinal questions with five possible response for each would normally require construction of $n \times 4$ additional independent variables absorbing many degrees of freedom. For example the attitudinal clusters are comprised of a set of seven questions each with five responses so that a total of $35 - 5 = 30$ independent variables would be required using conventional factors. Cluster analysis compresses these into four clusters which, after dropping a reference cluster, requires only three (dummy) variables to capture the same information, saving 27 degrees of freedom. All told we reduce 13 questions that would ordinarily require defining 60 independent binary variables to a set of six independent variables that capture essentially the same information while simplifying the narrative considerably.

3.1 Data collection

In October 2009, faculty and students from Northwest A&F University (PRC) and Cornell University (USA) conducted a survey of 897 farm households (FHs) in five township/16 villages including Yingtou (110 FHs), Huaiya (165 FHs), Jinqu township (201 FHs) in Mei County, Shaanxi province and Songshu (177 FHs), Hongbao township (244 FHs) in Qingshui County, Gansu province. Interviewed farmer households were selected at random according to family wealthy level and 25-30 percent of total families in each village were surveyed. Investigators conducted one-on-one interviews and filled in the questionnaires for each farm household. In total, 897 questionnaires were issued. Accounting for missing variables we obtained 858 valid questionnaires.

3.2 Independent variables

Table I summarizes each of the variables from the data that have been used in the analysis. Each household has lands in possession of 6.50 Mu (about 1 acre) and an average annual income of RMB 21,422 (approximately \$3,800). About 36.05 percent of total income is from agriculture, and total assets average to RMB 122,206.25 (\$17,971); the average household debt is RMB 13,923 (\$2,047).

Some key respondent characteristics are reported in Table II both looking at the data collectively and also looking separately at the two counties from where the data were collected. There are some variations in respondent characteristics between the two counties. For example Qingshui County has an average of only 13.08 percent of income contributed by agriculture while respondents from Mei County average at about 56.43 percent. Respondents also appear to have more assets on average in Mei County then in Qingshui County. While Mei County averages asset size of RMB 157,366.23 and Qingshui County is lower at RMB 82,555.

In addition to the data presented above 41.7 percent of surveyed farmers were credit worthy as evaluated by cooperatives or banks, 28.9 percent of them did not know whether they were credit worthy, and 29.4 percent were not credit users or credit worthy. The investigation also revealed that 44.2 percent of surveyed farmers were "very satisfied" and "relatively satisfied" about the current group guarantee mechanism. Although most surveyed households' willingness to participate in group guarantees are strong, the actual participation rate was only 15 percent. Given the prominence of, and promise of, the group guarantee mechanism this is a surprising result. But it is important to consider that not all farm households borrow from formal markets.

3.3 Cluster descriptions

Why farmers borrow or not, or participate in group guarantees or not is likely not tied to simple demographic or farming variables but through complex endogenous relationships determined by attitudes toward banks and guarantees, risk aversion, and social networks, trust and peer interactions. To account for these endogenous variables we define three cluster variables based on specific questions in the survey designed for this purpose. The first set of variables queried respondents on their attitudes toward lenders and group guarantees resulting in four distinct clusters. The second set of variables queried farmers on attitudes toward risk resulting in two distinct clusters; and the third created three clusters from a set of questions querying the respondent on peer influences to capture social networking.

3.3.1 Bank perceptions and group guarantees clusters. The Bank Perception cluster was created by using a number of survey questions that were trying to gain a qualitative assessment of how the sample feels about banks. This is a complex emotion to measure and the questions and variable are not all-comprehensive, however this feeling is important to assess because feelings about the banking system might supersede opinions about the group guarantee itself. We expect that this cluster will give us some indication of whether our sample chooses to participate in group guarantees. The prediction is that a more positive perception about banks is likely to positively affect participation in group guarantees. There are four clusters, each of which are uniquely identified and named (Table III):

(1) *The optimist* – while this group does not perceive their banks to be perfect, respondents in this segment responded more positively to questions about how they feel about banks. There was in this group the sentiment that RCC

Table I.
Summary of key demographic variables

Variable	Variable explanation	Mean	SD	Min	Max
County	1-Qingshui 2-Meixian, indicates which county respondent was based. Added to cover for any location-based fixed effects	1.53	0.50	1.00	2.00
Sex	0-Male 1-Female	0.29	0.45	0.00	1.00
Age	20-30 years old = 1, 30-40 years old = 2, 40-50 years old = 3, over 50 years old = 4	2.95	0.89	1.00	4.00
Family size	Number of people in the household	4.69	1.46	1.00	16.00
Education level	Illiterate = 1, not graduated from primary school = 2, primary school = 3, not graduated from secondary school = 4, secondary school = 5, the University did not graduate = 6, college graduates = 7	2.66	1.50	0.00	6.00
Total_land_holdings		6.50	3.81	0.00	60.00
Total_income of respondent	Annual household income	20,939.67	16,699.94	3.80	98,000.00
Percentage income from agriculture	Agricultural income accounted for family total income ratio (%)	36.60	34.37	0.00	100.00
Total declared assets	Farmer's family total assets (RMB)	125,115.00	151,767.70	3,000.00	2,740,000.00
Compulsory guarantee	0-not made compulsory by lender; 1-made compulsory by lender	0.39	0.49	0.00	1.00
Member of cooperative	0-not member of cooperative 1-member of cooperative	0.10	0.30	0.00	1.00
Risk approach	Cluster description given. 1 dummy variables with "The Risk-Averters" as reference	2.43	1.12	1.00	4.00
Bank perception (Ref group-The Optimist)	Cluster description given. 3 dummy variables with "The Disillusioned" as reference	2.33	0.79	1.00	3.00
Social impact (Ref group-The Friend)	Cluster description given.3 dummy variables with "The Loners" as reference	2.42	1.12	1.00	4.00
Amount of non_formal loans	Discrete variable: 0-no informal loans; 1-informal loans	0.47	0.50	0.00	1.00
2-amount of non_formal loans	Continuous variable – amount of informal loans from friends, relatives, money lenders and pawnshop owners	6,285.41	13,145.31	0.00	165,000

Area (No of respondents)	Item	Family size	Family annual income (RMB)	Average family total assets (RMB)	Land size (Mu)	Agricultural income proportion (%)	Average debt (RMB)
Total (883)	Minimum	1	420	3,000	0.8	0	0
	Maximum	16	100,000	1,000,000	60	100	140,000
	Average	4.69	21,422	122,206.25	6.5	36.05	13,923
	Standard	1.46	17,894	124,467.71	3.81	34.02	20,917
Qingshui County (415)	Minimum	1	420	3,000	0.9	0	0
	Maximum	10	100,000	1,000,000	16	100	140,000
	Average	4.5	29,393	82,555.95	5.85	13.08	12,702
	Standard	1.37	19,767	92,205.12	2.18	20.9	19,696
Mei County (468)	Minimum	1	1,000	10,000	1	0	0
	Maximum	16	100,000	1,000,000	60	100	120,000
	Average	4.9	12,450	157,366.23	7.27	56.43	15,298
	Standard	1.52	9,440	138,153.92	4.85	30.23	22,155

Note: We use the maximum possible *N* that is available

Table II.
Summary of
respondent
characteristics
by county

Bank perception	My local RCC or bank cares about the welfare of farmers Mean	My local RCC or bank cares about me and my household Mean	Loan products from my local RCC or bank are flexible enough to meet my ability to repay when I sell my products/at harvest, etc. Mean	My local RCC or bank will provide loans to agriculture even when there is a downturn in the agricultural economy Mean	I am satisfied with the lending practices of my RCC or bank Mean	I am satisfied with the services provided by my RCC or bank Mean	I can find suitable channels to get help or to file complaints if I am not satisfied with the financial services provide by my RCC or bank Mean
The optimist	4.250965	3.416988	3.96139	3.544402	4.169884	4.247104	2.513514
The indifferent	3.380952	2.989418	3.449735	3.312169	3.015873	3.005291	2.21164
The realist	2.179688	1.902344	3.085938	2.867188	2.925781	2.890625	2.039063
The disillusioned	1.308901	1.21466	3.057592	2.513089	2.21466	2.282723	1.675393

Notes: Scale – 1, strongly disagree; 5, strongly agree

Table III.
Cluster groupings
for bank perception

products are flexible and meet consumer demands and that RCC does care about the welfare of farmers and that of their families with an average response of 4.25. They also responded positively with an average 4.24 in response to a query regarding their satisfaction with services provided by formal lenders.

(2) *The indifferent* – the survey questions used allow respondents to maintain a neutral stance and not express their emotion either way. The mean does deviate from the neutral stance denoted by 3, with the variations from 3.44 the average response to the question regarding loan flexibility to 2.21, the response to whether they could find channels for complaining about formal lender services if wanted to.

(3) *The realist* – while this group tends to disagree with the statement that formal lending institutions actually care about them and their family with an average of just 1.90 in response to that question, they are more neutral about other topics such as on their satisfaction with the lending practices of the formal lending institution with an average response of 2.93.

(4) *The disillusioned* – this group strongly believes that the banking system does not care about their welfare or the welfare of their households. This group is also of the opinion that formal loan products are really inadequate to meet their needs and their answers reflect a general fear that banks will come down hard on them when they are not doing well financially. While there is some variation across the different questions, for examples respondents in this category are neutral about whether loan products are flexible with a mean of 3.06 overall there is a consistently negative perception of formal lenders. For example respondents in this category strongly disagree with the statement that formal lenders actually care about them with a mean of just 1.21.

It is important to note that responses to some questions for instance the one regarding filing of complaints were consistently low for all groups ranging from 2.51 for the optimist category to 1.67 for the disillusioned category. However for all the questions the variation from disillusioned to optimist is from high to low.

In our regressions we use the optimist as a reference group. The rationale behind this is to see if a growing trend of negative sentiment about banks will influence the decision to participate in group guarantees.

3.3.2 Risk attitudes clusters. We identified two distinct clusters on risk attitudes representing attitudes toward risk and risk aversion. The two cluster groupings are summarized in Table IV:

(1) *The risk averters* – as Table IV indicates the response across all the three questions were similar for this category with a mean of three. This mean indicates that this group generally tends to be more cautious with their approach. They admit to being less open with newer technologies and newer products. They could in effect be described as followers, who are uncomfortable with being the initiators or at the forefront of adoption.

(2) *The risk takers* – this group generally identifies as being more comfortable with taking risks with newer technologies and techniques with constant mean of five across all the three questions.

In our regressions we use the risk averters as the base reference group. The rationale behind this is to observe whether being more comfortable with uncertainty and risk affects the participation decision.

3.3.3 Peer group and social network clusters. Whether a borrower interacts with many or few other members will likely influence their group guarantee activities. Tight networks involve a great deal of trust and we hypothesize that those respondents who are part of large social networks are likely more trusting and thus more likely to participate in a guarantee program. On the other hand members of a social network may also have more access to informal credit and thus may not be large borrowers. The three cluster groupings are summarized in Table V:

(1) *The friend* – this group is unwilling to admit that they would not trust another person enough to not guarantee their debts and disagree strongly with the statement with an average of just 1.08 that they would not ask another villager to sign a group guarantee. They are slightly less welcoming about guaranteeing someone else's debt but with an average of 1.94 the response still remains mostly negative

(2) *The distant* – this group while still disagreeing with the idea they would be unable to find someone to guarantee their loans were leaning toward being more cautious with an average response of 1.98 to the question asking if they would not want to ask another villager to sign a group guarantee as opposed to an average of 1.08 in the previous group.

(3) *The distrusting* – this group is agreement in most of the statements that were presented to them with an average response of 3.17 on the statement asking them if they do not want to guarantee someone else's debt. They also seem to not want to ask others to guarantee their own debt with an average response of

	I am willing to accept greater production risks to increase the chance of higher profits	I am willing to take risks with new technologies before I see good results in other farms	I am willing to take risks with new management practices before I see good results in other farms
Risk cluster	Mean	Mean	Mean
Risk averter	3	3	3
Risk taker	5	5	5

Table IV.
Risk attitude clusters

Notes: Scale – 1, unwilling to accept risk; 5, willing to accept risk

Social impact	I do not want to ask another villager to sign a group guarantee	I could not find someone to provide a third-party (individual not group) guarantee	I do not want to have to guarantee another villager's debts
The friend	1.08	1.45	1.94
The distant	1.98	2.00	2.00
The distrusting	2.99	2.72	3.17

Table V.
Peer group and social network clusters

Notes: Scale – 1, strongly disagree; 5, strongly agree

2.99 to the statement querying if they would not want to ask someone else to sign a group guarantee.

The reference group used in the regressions is the Friend. This variable is designed to help us to see how a growing wariness about providing guarantees and asking others to provide guarantees affects participation in group guarantees.

3.4 Regression models

We are interested in identifying whether there are distinct characteristics between farmers who have or do not have formal debt or are members of a group guarantee. As discussed above we constructed our survey in order to define specific instruments and from these we define the four dependent variables as:

Category 1 – group member with formal debt

Category 2 – group Member with no formal debt

Category 3 – not group member with no formal debt

Category 4 – not group member with formal debt

Of 894[1] respondents we find 86 (9.6 percent) in Category 1, 41 (4.6 percent) in category 2, 529 (59.2 percent) in Category 3, and 238 (26.6 percent) in Category 4. Of these 60.7 percent indicated that in their local RCC a group guarantee was compulsory and overall 36.2 percent indicated that they had formal debt.

We first ran a multinomial Logit for the purpose of obtaining a valid Hausman[2] test for the independence of irrelevant alternatives on the four categories. We were unable to reject the null hypothesis for all but the Category 4-Category 3 pairing. Because of these results we could not continue on to use the results of the multinomial Logit. Instead we decided to proceed with using binomial logistic regression. The general story line between the two approaches will be the same, but using four independent binary Logit regressions with a robust estimator allows for a simpler, more-direct, interpretation of the results

3.4.1 Binary logistic regression. We use a standard binary Logistic regression of the form:

$$p\left(y = 1/x_i\right) = \frac{e^{\left(\beta_0 + \sum_{i=1}^{k} \beta_i x_i\right)}}{\left(1 + e^{\left(\beta_0 + \sum_{i=1}^{k} \beta_i x_i\right)}\right)} \quad (1)$$

where $\beta_0 + \sum_{i=1}^{k} \beta_i x_i$ is the characteristic equation of the Logistic function. The parameter estimates of this characteristic equation, $\hat{\beta}_i$, refer only to the change in the characteristic equation itself and not the left hand frequency measure. We therefore compute the marginal effects for each estimated coefficient using.

$$\eta_i = \frac{\hat{\beta}_i e^{\left(\hat{\beta}_0 + X\hat{\beta}\right)}}{\left(1 + e^{\left(\hat{\beta}_0 + X\hat{\beta}\right)}\right)^2} \quad (2)$$

The marginal effects indicate the direct change in the dependent variable (i.e. Categories 1-4) given a change in the underlying independent variable.

4. Regression results

The following table presents the results of each of the four binary logistic regressions that were run. While the regression was run using the informal loan variable both as a continuous and discrete variable, the results from both regression were very similar, which is why just the results from the regression using informal loans as a discrete binary value (1 = informal loan, 0 otherwise) is presented.

5. Key findings

We present in Table VI the raw Logit scores for the characteristic equation and the marginal effects. In what follows we discuss exclusively using the marginal effects. One of the key findings of this model is the role of the compulsory guarantee. The significant role of this variable is a clear indication that group guarantees are clearly not anyone's first choice. A respondent is 17 percent ($p = -0.00$) more likely to belong in the category which belongs to group guarantees with formal debt if providing group guarantee's is essential for access to get credit.

Basically the results indicate that respondents are more likely to be in a group guarantee if their lender (formal) requires it of them for loan eligibility. If their lender puts no such requirement then they are much less likely to be in the group guarantee. This finding provides further evidence of the challenges faced by group guarantee in the context of China discussed earlier in the paper and the shortcomings of this strategy as a policy intervention. Table VII provides a detailed breakdown of this variable for our entire data set.

Table VII indicates that 87.21 percent of the respondents who are group members with formal debts say that their formal lender requires them to provide a group guarantee in order for them to get a loan, while 68.49 percent of the respondents who are not in groups but have formal debt indicate that their formal lenders do not require them to get a group guarantee to access formal credit products.

The county variable which was incorporated to account for fixed locational effects comes out as significant in two of the regressions. While there are differences across the two counties as the paper notes earlier, those differences have already been captured by variables included in the regressions. These significance in the regression is more likely attributable to unobservable characteristics like soil quality and social and cultural differences across the counties. As the regression results reveal respondents are 9 percent ($p = 0.003$) less likely to belong to the category "Group Member with formal debt" if they live in the Meixian county as opposed to the Qingshui county. Respondents are also 10 percent ($p = 0.02$) more likely to belong to the category that are not group members and no formal debt if they live in Meixian county.

Age appears to be a particularly significant demographic variable. Interestingly, age does not affect whether a farmer borrows under a guarantee, but yet it appears that older individuals are less likely to guarantee the debt if they are not also borrowers (less likely by 2 percent, $p = 0.02$). In addition, older respondents are almost 4 percent ($p = 0.04$) more likely to belong to the category which is not part of group guarantees but has formal debts. The results seem to indicate that belonging to a higher age group makes it less likely that one will take on formal loans or belong to a guarantee group. We speculate that being older tends to make farmers more risk averse toward credit products from formal institutions, and while they might be willing to participate in a guarantee group if they too are borrowers, they are not willing to risk their collateral or savings if they are not direct beneficiaries. Hence this may be a capital preservation

| Variables | Group member with formal debt | | | Group member with no formal debt | | | Not group member with no formal debt | | | Not Group Member with formal debt | | |
	Coefficient	Average marginal impacts	p > z (significance)	Coefficient	Average marginal impacts	p > z (significance)	Coefficient	Average marginal impacts	p > z (significance)	Coefficient	Average marginal impacts	p > z (significance)
County	-1.33**	-0.09	3.00E-03	-0.09	-3.45E-03	0.88	-0.08	-0.02	0.72	0.56*	0.10	0.02
Sex	0.41	0.03	0.18	-0.05	-1.93E-03	0.90	0.03	0.01	0.87	-0.17	-0.03	0.37
Age	-0.03	-2.33E-03	0.83	-0.49*	-0.02	0.02	0.27**	0.06	2.00E-03	-0.20*	-0.04	0.04
Family size	-0.08	-0.01	0.39	1.06E-03	4.23E-05	0.99	0.03	0.01	0.55	-0.02	0.00	0.67
Education level	0.16	0.01	0.08	-0.17	-0.01	0.17	-0.02	-0.01	0.66	0.00	0.00	0.95
Total_land_holdings	0.02	1.59E-03	0.40	-0.03	-1.09E-03	0.58	-0.0411388	-0.01	0.06	0.041	0.01	0.07
Total_Income of respondent	1.46E-05	1.03E-06	0.17	8.59E-06	3.44E-07	0.53	-2.03E-06	-4.44E-07	0.72	0.00	0.00	0.73
Percentage income from agriculture	3.52E-03	2.47E-04	0.50	-2.43E-03	-9.72E-05	0.74	-7.75E-04	-1.70E-04	0.79	0.00	0.00	0.86
Total declared assets	1.27E-06	8.92E-08	0.27	-1.17E-06	-4.69E-08	0.52	-2.1E-06**	-4.60E-07	0.01	1.65E-06*	0.00	0.03
Compulsory guarantee	2.47**	0.17	0.00E+00	1.47**	0.06	0.00E+00	-0.70**	-0.15	0.00E+00	-0.44**	-0.08	0.01
Member of cooperative	0.56	0.04	0.21	0.59	0.02	0.29	-0.03	-0.01	0.91	-0.30	-0.06	0.29
Risk approach (Ref group-The Risk-Averter)	0.57*	0.04	0.04	0.41	0.02	0.25	-0.38**	-0.08	0.01	0.13	0.02	0.43
Bank perception (Ref group-The Optimist)												
The realist	-0.61	-0.04	0.14	-0.20	-0.01	0.66	0.56**	0.13	0.01	-0.37	-0.07	0.11
The indifferent	-0.59	-0.04	0.09	-0.96*	-0.04	0.05	0.41**	0.09	0.04	-0.05	-0.01	0.82
The disillusioned	-0.30	-0.02	0.39	-1.21*	-0.05	0.03	0.70**	0.15	1.00E-03	-0.44	-0.08	0.06
Social impact (Ref group-The Friend)												
The distant	0.29	0.02	0.45	-0.13	-0.01	0.80	0.18	0.04	0.40	-0.19	-0.04	0.43
The disillusioned	-0.12	-0.01	0.73	0.02	6.25E-04	0.97	0.28	0.06	0.15	-0.23	-0.04	0.27
Amount of non_formal loans (discrete)	-0.22	-0.02	0.42	-0.20	-0.01	0.58	0.05	0.01	0.73	0.07	0.01	0.67
Constant	-2.68**		0.01	-1.37		0.27	0.06		0.91	-1.13		0.06

Note: **, *Significant at 1 and 5 percent levels, respectively

Table VI.
Binary logit
regression results for
four distinct group
membership/ debt
use categories

Does your current formal lender require a group guarantee in order for you to get a loan?	Group member with formal debt	%	Group member with no formal debt	%	Not group member with no formal debt	%	Not group member with formal debt	%	Total
No	11	12.79	12	29.27	357	67.49	163	68.49	543
Yes	75	87.21	29	70.73	172	32.51	75	31.51	351
Total	86		41		529		238		894

Table VII.
Percentage of
farmers reporting
whether group
guarantee is
mandatory

strategy. This is supported by the finding that older farmers are most likely to have no formal debt at all and less likely to participate in group guarantees at all.

The risk attitude cluster variable indicates that both greater indebtedness and participation in group guarantees are perceived as high-risk behaviors, which the "wary" from among respondents want to avoid. Belonging to the risk-takers group means that respondents are 4 percent ($p = 0.04$) more likely to belong to the category with farmers who are members of group guarantees and have formal debt. The effect is even stronger in the other direction. If a respondent belongs to the risk-takers category they are nearly 8 percent ($p = 0.01$) less likely to belong in the category which is not a group member and has no formal debt.

The Bank perception cluster shows up as significant in some of the regressions. This indicates that the perception of the formal lender plays an important role in the utilization of credit products. It is therefore a relevant consideration when analyzing participation in group guarantees. Increased mistrust of the bank makes it less likely that farmers will belong to the category with group guarantees but no formal credit. The likelihood moves from 4 ($p = 0.05$) to 5 percent ($p = 0.03$) as the group shifts from The indifferent to the disillusioned. The inverse also stands true with increased dissatisfaction with banking services making it more likely that respondents will belong to the category which are not group members and do not take formal debt by 15 percent ($p = 0.001$) in the case of the disillusioned group.

Another interesting finding is the lack of significance of informal loan either as a discrete or as a continuous variable. This is important because it appears from this result that access to or the quality of informal loans appears to not be affecting the decision to participate in a group guarantee. Correspondingly, the social impact cluster does not show up as significant in the model which is surprising. It appears to indicate that willingness to guarantee and ask for guarantees do not appear to be the key issue that respondents have with guarantees.

The total declared assets variable's impact indicates that greater asset size(an impact of -4.60E-07 per unit change in asset) implies a greater likelihood of belonging to a category which utilizes formal credit products, but the role on participation in group guarantees is not clear.

6. Conclusions

This paper investigated group guarantees among Chinese farmers in Shaanxi and Gansu provinces. An extremely important observation according to our data is that most farmers appear to be part of group guarantees only because they have to in order to get access to formal credit products. 87.21 percent of the people who belong to groups and utilize the formal credit products belong to this category because their lenders have made paid participation in groups compulsory for access to credit. We combine cluster analysis and binary logistic regressions to investigate the factors that influence whether or not a farmer participates in a group guarantee and borrows within the group guarantee. Clusters refer to attitudes toward rural lenders and group guarantees, risk aversion, and social networks. We found that attitudes toward banker matters as does risk aversion. These characteristics matter. We do not find that social networks are influential which is probably because of the mandatory characteristics of the group guarantee mechanism.

From these results we believe that not all farmers benefit from the guarantee program. The evidence appears to be clear and strong that the mandatory nature of group guarantees actually dampens credit demand. Evidence suggests that this may be

a risk rationing effect; that guaranteeing another's liability places collateral at risk in no different form than collateral is placed at risk for an individual's loan; indeed one can imagine a systemic event that places both the borrowers and guarantor's collateral at risk. That higher asset farm households are more likely to participate in group guarantee lending than lower asset farmers suggests that this may be true. While some farmers have no doubt benefited from group guarantee lending, further investigation is needed to determine whether the guarantee requirement actually excludes, impedes, or rations farmers from accessing rural credit.

While these results raise policy issues in regards to implementing group guarantees, we are hesitant to suggest that these responses should be broadly applied to China as a whole. This is largely due to the way that group guarantees are implemented in different regions, the determination of credit worthiness, local credit markets, and local managers. Nonetheless, this study raises some important policy issues. One that stands out is the statistical significance of the compulsory measure which captures whether the local RCC requires a guarantee or not. This is positive only for those participating in the guarantee. For those not borrowing under a guarantee, or acting as a guarantee this is negative. This strongly suggests that local enforcement of the guarantee matters, and that farmers use the guarantee only because it is required of them. But we also find that how farmers perceive their lenders matters. For example, the "optimist" cluster which has the most positive view of their lenders are more likely to participate in a group guarantee and provide guarantees, this is an important issue. Should the CBRC want to see wide-spread implementation of group guarantees, the relationship between lender and borrower is an important factor that ought not to be ignored. Finally, it is believed that group guarantees work because of the strength of social networks. While this might hold true in self-help group lending activities with joint liability under Grameen-style micro-credit elsewhere, it does not appear that CBRC or RCCs should rely on social networks as the basis of success in group guarantee lending since none of the social network variables were significantly different from zero.

Notes

1. We use the maximum available N
2. Results provided in appendix

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Technical and allocative efficiency of irrigation water use in the Guanzhong Plain, China

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ABSTRACT

Due to increasing water scarcity, accelerating industrialization and urbanization, efficiency of irrigation water use in Northern China needs urgent improvement. Based on a sample of 347 wheat growers in the Guanzhong Plain, this paper simultaneously estimates a production function, and its corresponding first-order conditions for cost minimization, to analyze efficiency of irrigation water use. The main findings are that average technical, allocative, and overall economic efficiency are 0.35, 0.86 and 0.80, respectively. In a second stage analysis, we find that farmers' perception of water scarcity, water price and irrigation infrastructure increase irrigation water allocative efficiency, while land fragmentation decreases it. We also show that farmers' income loss due to higher water prices can be offset by increasing irrigation water use efficiency.

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Introduction

Due to water scarcity, irrigation plays an important role in agricultural production in North China. Huang et al. (2006) points out that widespread irrigation is required to keep up and expand agricultural outputs, particularly wheat and maize, but also to alleviate poverty. However, water scarcity in the region has been worsening due to accelerating industrialization and urbanization, but also because of environmental challenges, such as climate change and water pollution (Jiang, 2009). These developments have led to increased competition among the main water users, i.e. agriculture, industry and households.

Irrigation consumes 60% of total annual water resources in *inter alia* the Guanzhong Plain, which is a region facing severe and increasing water scarcity. In the area, 75% of grain production comes from irrigated land which accounts for 50% of total arable land. Expansion of grain production, and thus of irrigation, is needed to feed China's large and still growing population. However, water has higher marginal returns in industry and the residential sector. Under such circumstances, it is imperative for agriculture to improve its water use efficiency (Lybbert and Sumner, 2012).

This goal of the paper is to measure the efficiency of farmers' irrigation water use and identify its determinants, based on a sample of 347 farmers in the Guanzhong Plain. The paper contributes to the literature in the following three aspects. First, it focuses on both technical and allocative efficiency. Water use efficiency is commonly defined as yield per m³ water. See, for instance, Wang et al. (2010). This measure is biased and inappropriate, however, because it ignores the fact that yield is not produced by a single input, water, but by multiple inputs including water, but also fertilizers, seeds, machinery and labor. Several researches have recognized this and analyzed technical efficiency of irrigation water use, while controlling for the contributions of all other inputs (Karagiannis et al., 2003; Speelman et al., 2008, among others). For instance, based on data on 50 vegetable farms in Greece, Karagiannis et al. (2003) analyzed input-specific technical efficiency as a measure of water use efficiency. However, technical efficiency analysis does not measure a farmer's ability to allocate irrigation water and other inputs to their cost-minimizing input proportions. For that purpose, allocative efficiency analysis is needed. To the best of our knowledge, there are no analyses of allocative efficiency of irrigation water use. This paper fills this gap by simultaneously estimating a production function, and its corresponding first-order conditions for cost

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minimization, to measure this latter kind of efficiency. In addition, it measures technical and economic efficiency.

Secondly, in a bid to get insight into the determinants of technical and allocative efficiency, the paper does not only consider farm-specific characteristics, like farm size, and socioeconomic features, such as farmer's age and education, but also a farmer's perception of water scarcity. As argued by Folmer (2009) and Folmer and Johansson-Stenman (2011), ignoring the latter kind of variables leads to model under-specification, and thus to biased estimators of the coefficients of the standard explanatory variables, like farm and farmer characteristics, and to invalid inference. Furthermore, if perception turns out to be a determinant of efficiency, it is a potential policy handle in that improving perception via e.g. extension, may induce farmers to reduce their water use. (Note that the literature has so far paid little attention to perception of water scarcity and its potential as a policy instrument.)

Thirdly, the paper provides support to water pricing as a policy handle. In China, the use of this policy instrument is still under debate. Huang et al. (2010) argues that the price of irrigation water in China is too low to induce farmers to save water. However, policymakers fear that higher prices will jeopardize farmers' income and further widen the gap between rural and urban residents (Lohmar et al., 2007). Little research has been conducted to quantify the effect of water price on income. We test whether the income loss due to higher irrigation water price can be offset by more efficient use of water.

The structure of the paper is as follows. Section "Methodology" presents the methodological framework. Sections "The conceptual model and the Structural Equation Model (SEM)" and "Empirical results" discuss the data and the empirical results. Section "Discussion and policy recommendations" presents the conclusions and policy recommendations.

Methodology

Single-factor technical, allocative and economic efficiency

Since Farrell's (1957) pioneering work, the three efficiency measures technical, allocative and economic efficiency, have been extensively used to assess economic performance of various economic sectors. This also applies to agriculture, where a substantial literature on efficiency of agricultural production has developed. Few studies, however, focus on efficiency of a particular input, such as water. To gain insight into the efficiency of the single input irrigation water, we present in this section the notions of *single-factor technical efficiency* (*SFTE*), *single-factor allocative efficiency* (*SFAE*) and *multifactor economic efficiency* (*MFEE*). These concepts, as introduced by Kopp (1981) and Kopp and Diewert (1982), are illustrated in Fig. 1.

In Fig. 1, there is a single output, *Y*, and two inputs *W*, i.e. irrigation water, and *X*, which denotes all other inputs, such as capital, labor, fertilizers and so on. F_1 is an isoquant which represents the production frontier at which a technically, perfectly efficient farmer uses least inputs to produce a given output. Point *P* is above the production frontier indicating that the farmer who produces at that point is technically inefficient.

Consider the isocost lines C_1, C_2 and C_3. Point *P* at C_1 is the actual cost at which the producer uses OW_1 of input factor *W* and *OE* of input factor *X*. Point E^* on C_2 denotes the cost where the use of *W* is technically efficient, given *X* (*OE*) and output. The isocost line C_3 is drawn tangent to the isoquant F_1 at point *D* where *W* and *X* are both allocatively efficient. The slope of C_3 (with negative sign) equals the ratio of the prices of *W* and *X*. X^* and W^* are intersections[1] of the
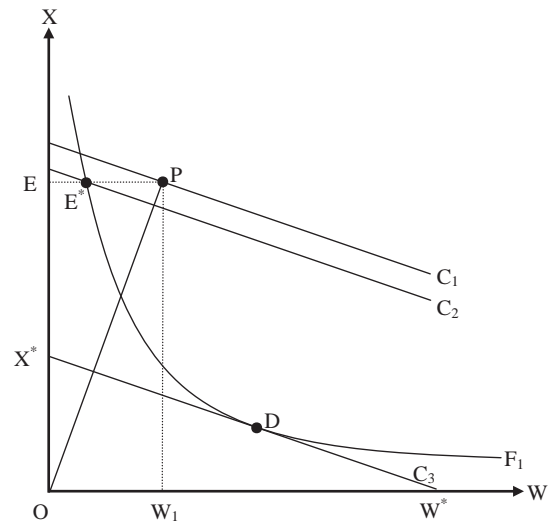
Fig. 1. Single-factor technical, allocative and multi-factor economic efficiency. Note: Figure is based on Kopp (1981) and Reinhard et al. (1999).

isocost line C_3 and the vertical and horizontal axis, respectively. C_3 is the cost at point *D*.

EE^* is the minimum feasible use of *W* conditional on a given level of input *X* (*OE*) and actual output. *SFTE* of *W* at point *P* equals EE^*/EP. From a cost perspective, single-factor technical cost efficiency (*SFTCE*) of *W* is the ratio between the cost when *W* is technically efficient and actual cost, that is, C_2/C_1. *SFAE* of *W* is the ratio between the cost at point *D* and the cost at point E^*, that is, C_3/C_2. Finally, *MFEE* is the product of *SFTCE* and *SFAE* and equals C_3/C_1. Since *MFEE* is determined as their product, the focus below will be on *SFTE* and *SFAE*. Below we label the three types of single factor irrigation water efficiencies as *IWTE*, *IWAE* and *MFEE*, respectively.

Measurement of irrigation water technical efficiency (IWTE)

Having introduced the concepts of *SFTE* and *SFAE* in the previous section, we now turn to the methodology of estimating these measures. In this subsection we pay attention to *SFTE*, in the next to *SFAE*.

Following Aigner et al. (1977), the general stochastic production function for cross sectional data is:

$$Y_i = F(X_i; \beta) \exp(v_i - u_i) \qquad (1)$$

For farmer *i*, production function (1) describes output Y_i as a function of a vector of inputs X_i and an error term made up of two components: $v_i \sim N(0, \sigma_v^2)$, representing the standard error term, and the non-negative error term u_i, which follows a half-normal distribution, reflecting the shortfall of a farmer's output from the production frontier, due to technical inefficiency.

A translog stochastic frontier production function is usually chosen for (1). For the *i*th farmer, the translog stochastic frontier production function with 4 inputs, reads:

$$\ln y_i = \beta_0 + \beta_w \ln w_i + \sum_{j=1}^{3} \beta_j \ln x_{ji} + \frac{1}{2} \sum_{j=1}^{3} \sum_{k=1}^{3} \beta_{jk} \ln x_{ji} \ln x_{ki}$$

$$+ \sum_{j=1}^{3} \beta_{wj} \ln w_i \ln x_{ji} + \frac{1}{2} \beta_{ww} (\ln w_i)^2 + v_i - u_i \qquad (2)$$

where y_i is output (wheat in the present study). The 4 inputs considered in the application below include: (1) x_{1i}, the sown area (*Land*); (2) x_{2i}, *Labor*; (3) x_{3i}, *Other inputs*; and (4) w_i, *Water*.

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[1] X^* is the quantity of *X* when cost (C_3) is incurred to purchase *X* only, while W^* is the quantity of *W* when cost (C_3) is incurred to purchase *W* only.

Following Schmidt and Lovell (1979), the first-order conditions of cost minimization imply that the technical rate of substitution equals the factor price ratio. To avoid identification problems, we arbitrarily choose w as numeraire. For farmer i, the first-order conditions are:

$$\ln S_{ji} - \ln S_{wi} - \ln(p_{ji}x_{ji}) + \ln(p_{wi}w_i) = \tau_{ji} \quad j = 1,2,3 \quad (3)$$

where

$$S_{ji} = \beta_j + \sum_{k=1}^{3} \beta_{jk}\ln x_{ki} + \beta_{wj}\ln w_i, \quad j = Land, \; Labor \; and \; Other \; inputs \quad (4)$$

In (3), p_{ji} is the price of the jth input, p_{wi} is the price of water and S_{ji} and S_{wi} are the partial derivatives (elasticity) with respect to input j and w, respectively. τ_{ji} is the error term which is normally distributed and can take both positive and negative values. (Note that τ_{ji} also corresponds to allocative inefficiency which is defined as the extent of failure to choose cost-minimizing factor proportions between the input j and the numeraire w. For further details, see Section "Measurement of Irrigation Water Allocative Efficiency (IWAE)"). If $\tau_{ji} > 1$, input x_i is underutilized relative to irrigation water; it is overutilized, if $\tau_{ji} < 1$.

Following Reinhard et al. (1999), IWTE for farmer i can be obtained by setting actual production equal to production under no technical inefficiency ($u_i = 0$), i.e. when using minimum feasible irrigation water w_i^F while producing the same level of output (y_i).

$$F(x_i, w_i^F; \beta)\exp(v_i) = F(x_i, w_i; \beta)\exp(v_i - u_i) \quad (5)$$

From (5), IWTE for individual farmer i can be obtained as:[2]

$$IWTE_i = \exp\left(\frac{-\varpi_i \pm \sqrt{\varpi_i^2 - 2\beta_{ww}u_i}}{\beta_{ww}}\right) \quad (6)$$

where

$$\varpi_i = \beta_w + \sum_{j=1}^{3}\beta_{wj}\ln x_{ji} + \beta_{ww}\ln w_i \quad (7)$$

Measurement of Irrigation Water Allocative Efficiency (IWAE)

We now turn to IWAE, i.e. irrigation water allocative efficiency when all inputs are adjusted to their respective cost-minimizing input proportions, given prices of all inputs, and output. As shown in Section "Single-factor technical, allocative and economic efficiency", allocative efficiency of irrigation water is the ratio between the cost at point E^* (C_2 in Fig. 1) and the cost at point D (C_3 in Fig. 1). Suppressing the subscript i, we have for C_2

$$C_2 = p_w w^F + \sum_{j=1}^{3} p_j x_j \quad (8)$$

At point D in Fig. 1 the producer is both technically and allocatively efficient. Hence, the minimum feasible cost of producing actual output Y at point D, $C^*(p, y)$, is:

$$C^*(p,y) = p_w w^* + \sum_{j=1}^{3} p_j x_j^* \quad (9)$$

The optimal inputs x_j^* and w^* are obtained by solving the Eqs. (2) and (3) with the allocative inefficiency term $\tau_{ji} = 0$, and the technical inefficiency term $u_i = 0$.[3]

Finally, from its definition IWAE is

$$IWAE = \frac{C^*(p,y)}{C_2} \quad (10)$$

Finally, from its definition, MFEE is obtained as:

$$MFEE = IWTCE * IWAE \quad (11)$$

where $IWTCE = C_2/C_1$.[4]

The Conceptual model and the Structural Equation Model (SEM)

Below we first develop the conceptual model, i.e. the model that describes the determinants of IWTE and IWAE (Section "The determinants of IWTE and IWAE"). Next, in Section "SEM", we present it as a Structural Equation Model (SEM).

The determinants of IWTE and IWAE

The scores for IWTE and IWAE are obtained from the Eqs. (6) and (10) in Section "Methodology". We assume that the explanatory variables discussed below apply to each of the two types of efficiencies, though possibly with different coefficients. Therefore, we use the catch-all label *Efficiency* in this section.

Endogenous explanatory variables

As an explanatory variable of both types of efficiency, we postulate Perception of water scarcity (*Perception*). This assumption is based on the growing evidence that economic behavior is strongly influenced by psychological factors including perceptions, expectations and habits (Folmer (2009), Folmer and Johansson-Stenman (2011) and the reference therein). The underlying mechanism is that perception increases intrinsic motivation which enhances environmentally friendly behavior (Lindenberg, 2001).

We take *Perception* as a latent variable or theoretical construct, i.e. a variable that refers to a phenomenon that is supposed to exist but cannot be directly observed (see e.g. Folmer (1984) and the references therein).[5] We measure the latent variable *Perception* by the following three items (observed variables), each measured at a 5 points scale:[6]

(i) *Perception 1 (Percep1)*: Irrigation water is scarce in my village.
(ii) *Perception 2 (Percep2)*: Irrigation water scarcity is worse now than before.
(iii) *Perception 3 (Percep3)*: Irrigation water will be scarcer in the next two years than it is now.

We expect a positive impact of *Perception* on *Efficiency*. This expectation is based on the assumption that farmers who clearly perceive water as a scarce input are likely to be intrinsically motivated to be efficient.

We do not only hypothesize an impact of *Perception* on *Efficiency*, but also vice versa. That is, we assume that efficient farmers perceive water scarcity less as a problem. We have not been able to find evidence for this hypothesis in the social science and economics literature. However, experts on irrigation in the Guanzhong Plain have pointed out in various in-depth interviews that efficient farmers have a more optimistic view on water scarcity (as measured by the above three observed variables) than less efficient farmers. Therefore, we test this hypothesis in the empirical analysis below.

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[2] For details, see Reinhard et al. (1999) and Tang et al. (2013a).
[3] Eqs. (2) and (3) make up a system of 4 nonlinear equations with 4 unknown optimal inputs x_1^*, x_2^*, x_3^* and w^*. We solved them using Matlab by setting the actual values as starting values (Rodríguez-Álvarez et al., 2004).

[4] Here C_1 is the actual cost.
[5] See Section "SEM" for the econometrics of handling latent and observed variables.
[6] Each item is presented as a statement with response categories ranging from fully disagree to fully agree.

Exogenous variables

We first discuss the exogenous explanatory variables of *Efficiency* and next those of *Perception*.

Age. Chen et al. (2009) shows that older farmers are more technically efficient than younger farmers. The explanation is that older farmers have more farming experience and thus have developed more efficient irrigation practices. Hence, we expect a positive effect on *Efficiency*.

Time spent on farming (Time). In the Guanzhong Plain, there is a growing number of part-time farmers who spend less time on irrigation; particularly they irrigate less frequently than their full time peers. This restriction reduces the possibilities for "precise irrigation" (right moment and adequate amount). Moreover, since they have off-farm income, farming activities, including irrigation, are likely to be less important to them than to full time farmers. Hence, we assume that part-time farmers are less efficient than their full time peers.

Land Fragmentation (Fragmentation). This variable is measured by the number of different plots a farmer cultivates. A large number of different plots indicates a high level of land fragmentation. The impact of land fragmentation on efficiency of agricultural production in general has been empirically investigated in China. Based on a sample of 1093 rice producers in South-east China, Tan et al. (2010) showed that land fragmentation is an important, negative, determinant of technical efficiency. For 339 rice producers in Zhejiang, Hubei, and Yunnan Provinces, Zhang et al. (2011) found that land fragmentation is hindering technical efficiency. To the best of our knowledge, the impact on irrigation water efficiency has not been investigated yet. We hypothesize that land fragmentation decreases *Efficiency*.

Irrigation infrastructure (Infrastructure). At the termination of the collective agricultural system in 1978, irrigation canals started to deteriorate due to reduced maintenance which, *inter alia,* has led to seepage (Wang et al., 2006).[7] In 1999, the World Bank started an irrigation infrastructure repair project in the Guanzhong Plain. However, not all canals have been repaired and presently there exist differences in irrigation infrastructure quality. We expect farmers located at repaired (cement) canals to be more efficient. Infrastructure takes the value 1 if the farmer is connected to a cement irrigation canal and 0 otherwise.

Income. Liu et al. (2008) found a positive impact of net per capita income on water-saving technology adoption in 10 provinces in China. The explanation is that possibilities to purchase and use more advanced technology increase with income. We thus assume a positive impact on *Efficiency*.

We now turn to the exogenous explanatory variables of *Perception*.

Income. We also hypothesize a positive income effect on *Perception* in that higher income allows the acquisition of information which in its turn may promote clearer perception.

Education. Education is measured as years of schooling in this study. We assume that educated farmers have clearer perceptions of irrigation water scarcity than uneducated because education

makes individuals more knowledgeable and able to interpret a complex phenomenon like the environment (Stapp, 1969). We hypothesize a positive impact on *Perception*.

Water price. Irrigation water price varies in the Guanzhong Plain, mainly because of scarcity. Wang et al. (2009) found that farmers respond to higher water prices by reducing water use. The reason is that water price signals the value of water. We therefore expect *Water price* to have a positive impact on *Perception*.

Precipitation. People form perceptions of their environment via signals and stimuli that they receive from it (Sudarmadi et al., 2001). In the case of irrigation water, *Precipitation* is an important signal. In the study area, precipitation, ranges from 137 mm to 220 mm during the growing season (from October to May). We hypothesize that *Perception* varies inversely with *Precipitation* in that in areas with more rainfall perception of water scarcity is lower.

SEM

The conceptual model above contains the latent variable *Perception* as well as several observed variables including the indicators that measure *Perception*. Both types of variables can be simultaneously handled by means of a Structural Equation Model (SEM). A SEM consists of two sub-models: two measurement models (Eqs. (11) and (12)) and a structural model (Eq. (13)) (Jöreskog, 1977; Jöreskog and Sörbom, 2001). The measurement models specify the relationship between the latent variables and their observed indicators[8] while the structural model represents the relationships between the latent exogenous and latent endogenous variables as well as the relationships among the latent endogenous variables. Specifically:

$$y = \Lambda_y \eta + \varepsilon \tag{11}$$
$$x = \Lambda_x \xi + \delta \tag{12}$$
$$\eta = B\eta + \Gamma\xi + \zeta \tag{13}$$

where y is a $p \times 1$ vector of endogenous observed variables, x a $q \times 1$ vector of exogenous observed variables, η an $m \times 1$ vector of latent endogenous variables, and ξ a $n \times 1$ vector of latent exogenous variables. Λ_y and Λ_x are $p \times m$ and $q \times n$ matrices of regression coefficients or loadings. B is an $m \times m$ matrix with β_{ij} representing the effect of the jth endogenous latent variable on the ith endogenous latent variable, and Γ is an $m \times n$ matrix with γ_{ij} representing the effect of the jth exogenous latent variable on the ith endogenous latent variable. Finally, ε and δ are $p \times 1$ and $q \times 1$ vectors of measurement errors of y and x, with covariance matrices θ_ε, and θ_δ, respectively. ζ is a vector of disturbances of the structural model. Its covariance matrix is Ψ. For identification, estimation, testing and modification indices we refer to Jöreskog and Sörbom (2001). Folmer and Oud (2008) discuss the theoretical and empirical advantages of using SEM.

In SEM notation the conceptual model presented in Fig. 2 reads:

$$\begin{bmatrix} IWTE \\ IWAE \\ Percep1 \\ Percep2 \\ Percep3 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \lambda_{3,1} \\ 0 & 0 & \lambda_{4,1} \\ 0 & 0 & \lambda_{5,1} \end{bmatrix} \begin{bmatrix} IWTE \\ IWAE \\ Perception \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \end{bmatrix} \tag{14}$$

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[7] In the Guanzhong Plain, a canal is used by a group of farmers. Irrigation water flows from the canal to the farmlands. Farmers are charged for the total amount of water withdrawn, including water lost during transportation due to seepage. If a canal is totally destroyed, the farmers who use it, have no longer access to irrigation water.

[8] Note that directly observed variables can be conveniently handled in the SEM framework by specifying an identity relationship in the measurement model between the latent variable and the corresponding observed variable.
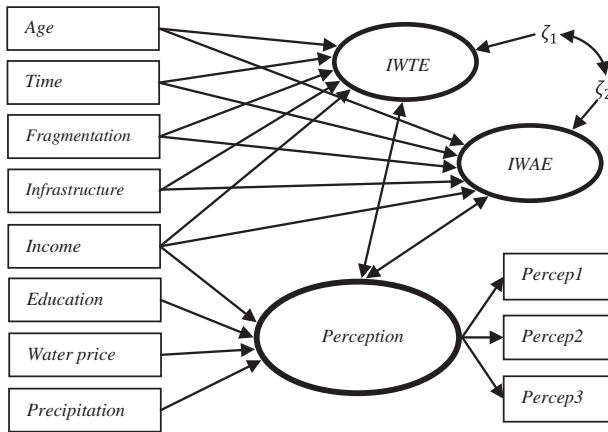
Fig. 2. The efficiency-perception model. (Error terms not included.)

$$\begin{bmatrix} Age \\ Time \\ Fragmentation \\ Infrastructure \\ Income \\ Education \\ Waterprice \\ Precipitation \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} Age \\ Time \\ Fragmentation \\ Infrastructure \\ Income \\ Education \\ Water\ price \\ Precipitation \end{bmatrix}$$

$$(15)$$

$$\begin{bmatrix} IWTE \\ IWAE \\ Perception \end{bmatrix} = \begin{bmatrix} 0 & 0 & \beta_{1,3} \\ 0 & 0 & \beta_{2,3} \\ \beta_{3,1} & \beta_{3,2} & 0 \end{bmatrix} \begin{bmatrix} IWTE \\ IWAE \\ Perception \end{bmatrix}$$

$$+ \begin{bmatrix} \gamma_{1,1} \gamma_{1,2} \gamma_{1,3} \gamma_{1,4} \gamma_{1,5} & 0 & 0 & 0 \\ \gamma_{2,1} \gamma_{2,2} \gamma_{2,3} \gamma_{2,4} \gamma_{2,5} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \gamma_{3,5} \gamma_{3,6} \gamma_{3,7} \gamma_{3,8} \end{bmatrix} \begin{bmatrix} Age \\ Time \\ Fragmentation \\ Infrastructure \\ Income \\ Education \\ Waterprice \\ Precipitation \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \zeta_3 \end{bmatrix} \quad (16)$$

$$\Psi = \begin{pmatrix} \psi_{11} & 0 & 0 \\ \psi_{21} & \psi_{22} & 0 \\ 0 & 0 & \psi_{33} \end{pmatrix} \quad (17)$$

Eqs. (14) and (15) are the endogenous and exogenous measurement models, respectively, and Eq. (16) is the structural model. (17) is the covariance matrix of the vector of structural error terms ζ.

From the conceptual model presented in Section "The determinants of IWTE and IWAE", it follows that there may be some common factors influencing the disturbances of *IWTE* and *IWAE*. To account for this, we specify ψ_{21} as a free parameter that is to be estimated. (Note the similarity to Seemingly Unrelated Regressions (SUR)).[9]

Empirical results

Data collection and descriptive statistics

The analysis is based on a cross-sectional dataset collected in a survey among 446 farmers in the Guanzhong Plain, for the crop year 2011, which runs from October 2010 to May 2011. Although

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[9] We acknowledge one of the reviewers' suggestion to adopt this approach.

virtually all farmers produce several crops, we only consider wheat farmers which is the main crop irrigated. Other crops such as corn and apple require no or little irrigation. *Output* is measured as yield of wheat times price.

The following multi-stage sampling procedure was applied. First, since irrigation in the Guanzhong Plain is organized by irrigation districts (ID), we sampled IDs at the first stage. Among the approximately 100,000 IDs, we chose the nine largest because of their well-structured irrigation infrastructure and substantial area coverage of approximately 80%. At the next stage, we sampled canals within the selected IDs. For each ID, we randomly sampled 2–12 canals proportional to its total number of canals. At the third stage, we sampled villages per canal. To account for differences in water availability between upstream and downstream areas, we randomly sampled 1 village from each stratum. The total number of villages sampled was 66. At the final stage, we randomly sampled 5–7 wheat farmers per village, resulting in 405 wheat farmers. Among them, 58 did not irrigate[10]; they were excluded from the sample which resulted in a sample of 347 farmers.

Face-to-face interviews were conducted by a group of interviewers consisting of Master and Ph.D students at Northwest A&F University majoring in agricultural economics. Before the interviews, a preliminary survey was held to test the structure of the questionnaire and the clarity of the questions. Based on the outcome of this survey, the ambiguous and unclear questions were revised. The interview was carried out in October, 2011 when the harvest was finished.

Data used in the stochastic frontier analysis include the quantity and price for each of the following inputs: (1) *Land* (measured in mu); (2) *Labor* (measured in man-days); (3) *Other inputs* (the sum of the monetary value of all other inputs including seeds, fertilizers, machinery and pesticides); and (4) *Water* (measured in m³). Table 1 presents descriptive statistics for the key variables included in the analysis and Table 2 for the indicators of perception.

The frontier model

The simultaneous Eqs. (3) and (4) were estimated by the Stata program by Kumbhakar and Wang (2006). We first tested the Cobb-Douglas versus the translog production function. The difference of the log likelihood test statistics follows a χ^2_{10} distribution (Battese and Coelli, 1995). We rejected the Cobb-Douglas specification at 1% significance level.[11]

The estimates of the translog model are reported in Table 3. Only 2 of the 14 variables (ln*Labor**ln*Water* and ln*Water**ln(*Other inputs*) are insignificant. The ratio $\frac{\sigma_u^2}{\sigma_u^2 + \sigma_v^2} = 44.76\%$ indicates that technical efficiency contributes 44.76% to the total variance of output.

The output elasticities of wheat yield with respect to each input are reported in Table 4. The results are in line with Tang et al. (2013a). The highest elasticity is for *Other inputs* (0.46), followed by *Land* (0.44) and *Labor* (0.1132). The elasticity of *Water* is 0.0812 indicating that a 1% increase in irrigation water leads to only a 0.0812% increase of output. The sum of elasticities with respect to the four inputs equals 1.09, indicating a (slightly) increasing return to scale.

The estimated distributions of the *IWTE*, *IWTCE*, *IWAE* and *MFEE* scores are shown in Fig. 3. The *IWTE*, *IWAE* and *MFEE* distributions are close to normal while the *IWTCE* distribution is skewed to the

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[10] The main reasons for the 58 farmers to abstain from irrigating are: (1) they are absent from the farm for most of the irrigation season; (2) they think there is no need for irrigation because rainfall is sufficient and (3) there is no irrigation infrastructure.

[11] The log likelihood for the Cobb-Douglas specification was −455.77; for the translog specification it was −133.38. So the χ^2_{10} statistics is 322.39. The 1% significance level with 10 degrees of freedom is 23.21.

Table 1
Descriptive statistics.

Variable	Unit of measurement	Min.	Max.	Mean	S.D.	Coefficient of variation
Yield	kg	200	20,000	2582	1820	0.70
Price of yield	Yuan/kg	1.5	3	2.02	0.10	0.05
Output	Yuan	400	38,800	5209	3659	0.70
Land	Mu	0.40	40.00	5.71	3.86	0.68
Labor	man-days	0.45	46.00	8.26	6.30	0.76
Water	m^3	38	9389	1535	1406	0.92
Other inputs	Yuan	157	20,100	2156	1612	0.75
PriceLand	Price of land in Yuan/mu	40.00	1500.00	241.99	193.65	0.80
PriceLabor	Price of labor in Yuan/day	30.00	200.00	73.25	27.25	0.37
Age	Years	26	77	53.08	10.07	0.19
Education	Years	0	12	6.64	1.70	0.26
Income	Yuan	1000	195,000	26,941	25,103	0.93
Time	—	1	5	3.80	1.44	0.38
Water price	Yuan/m^3	0.02	1.00	0.32	0.13	0.41
Fragmentation	—	1	15	2.74	1.75	0.64
Precipitation	mm	137	220	174.31	17.07	0.10
Infrastructure	—	0	1	0.52	0.49	0.94
IWTE	—	0.06	0.76	0.35	0.14	0.40
IWTCE	—	0.75	0.99	0.93	0.04	0.04
IWAE	—	0.64	0.98	0.86	0.07	0.08
MFEE	—	0.60	0.93	0.80	0.07	0.09

Table 2
Descriptive statistics for indicators of *Perception.*

Indicators	Strongly disagree (%)	Disagree (%)	Neither disagree nor agree (%)	Agree (%)	Strongly agree (%)	In total
Percep1	30.55	31.99	1.44	18.16	17.87	100
Percep2	14.12	42.36	10.09	19.02	14.41	100
Percep3	7.78	17.87	44.96	17.29	12.10	100

Table 3
The estimated translog production function.

Variable	Coefficient	S.E.
Constant	−8.0383***	0.9090
lnLand	−3.7634***	0.3023
lnLabor	0.4180***	0.1180
lnWater	0.3432***	0.0497
ln(Other inputs)	4.1463***	0.2881
lnLand*lnLand	−0.7910***	0.0605
lnLabor*lnLabor	−0.0601***	0.0089
lnWater*lnWater	−0.0423***	0.0050
ln(Other inputs)*ln(Other inputs)	−0.6157***	0.0487
lnLand*lnLabor	0.0955***	0.0139
lnLand*lnWater	0.0375***	0.0052
lnLand*ln(Other inputs)	0.6696***	0.0529
lnLabor*lnWater	0.0073	0.0072
lnLabor*ln(Other inputs)	−0.0527***	0.0189
lnWater*ln(Other inputs)	−0.0052	0.0073
σ_u^2	0.0329***	0.0082
σ_v^2	0.0406***	0.0035
Log likelihood	−133.38	

Note:
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

Table 4
Output elasticities.

Input	Land	Labor	Water	Other inputs	Sum
Elasticity	0.4444	0.1132	0.0812	0.4561	1.0949

right limit of 1. The mean value of *IWTE* is 0.35, indicating that given current technology and keeping other inputs constant, the same output can be produced by using 65% less water. This means that a large proportion of irrigation water is wasted. However, it

also indicates a substantial saving potential. *IWTCE* has a mean value of 0.93, which means that the inefficient use of water leads to a 7% increase of total cost.

IWAE measures farmers' ability to minimize cost using the optimal level of inputs. Its mean value is 0.86, indicating that not allocating the inputs at cost-minimizing proportions has led to a total cost increase by 14%. *MFEE*, which is the product of *IWTCE* and *IWAE*, has a mean value of 0.80. It shows that the total cost can be feasibly decreased by 20% while keeping output at the observed level.

On the basis of the above, we can draw the following conclusion. Since its cost accounts for only 9.85% of total cost, the price of irrigation water can be more than doubled (i.e. increased by the factor 2.03 to give the feasible cost decrease of 20%), without hampering farmers' income, if they improve efficiency by using irrigation water technically efficiently, and optimally allocating their inputs.

SEM

Before going into detail, we make the following observations. First, we assigned a measurement scale to the latent variable *Perception* (which is a prerequisite for identification) by fixing its variance (at 1). Secondly, the coefficients presented below are standardized.[12] (Finally, we estimated the model by means of LISREL 8.8 (Jöreskog and Sörbom, 2001). Because of the presence of ordinal variables, we analyzed a polychoric correlation matrix.

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[12] A standardized coefficient gives the standard deviation change in a dependent variable due to a standard deviation change in an explanatory variable. They are obtained by computing the z-scores and running the analysis using the z-scores, rather than the original scores of the variables. Standardized coefficients allow direct comparisons of the effects of the explanatory variables because their relative movements are the same. For variables measured in other units than z-scores, this does not hold.
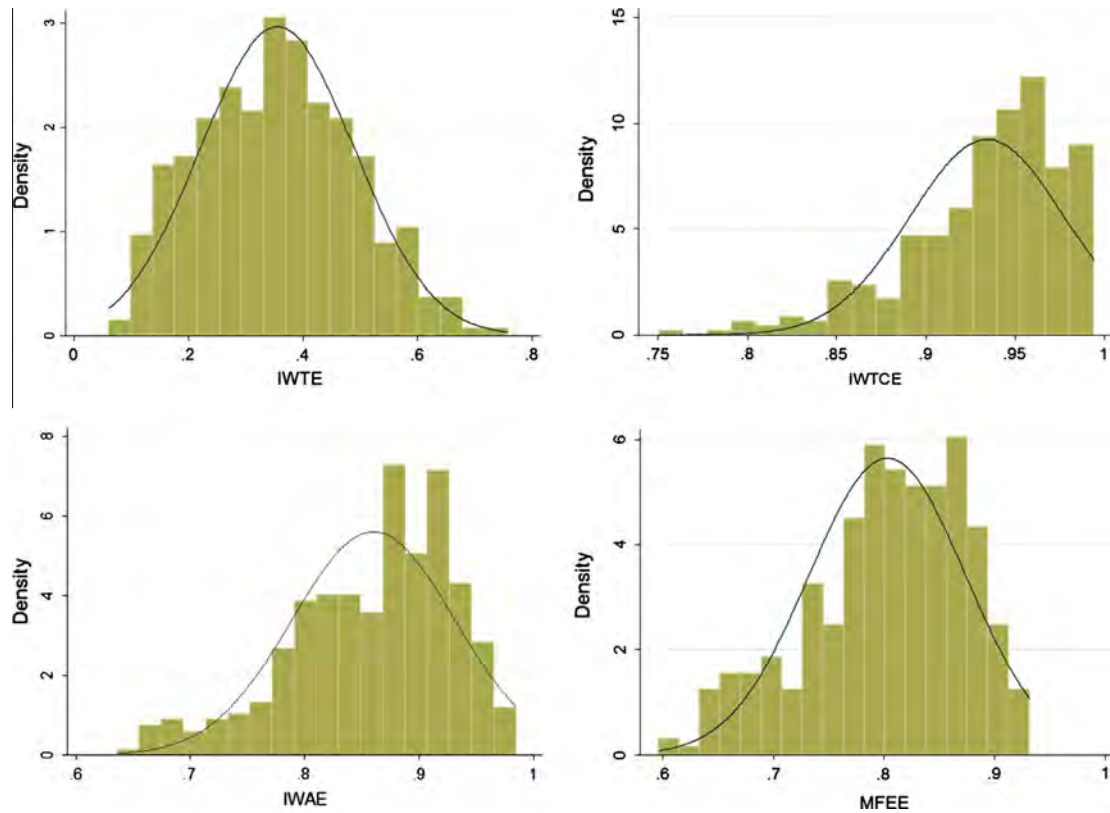
Fig. 3. Distribution of *IWTE*, *IWTCE*, *IWAE* and *MFEE* scores.

The measures of model fit are presented in Table 5. The *p*-values corresponding to the χ^2 statistics indicate the probability of obtaining a sample as the one at hand, if the hypothesized conceptual model is true. Since the *p*-value corresponding to the χ^2 statistic tends to be depressed, if the distribution of the observed variables deviates from normality (Bollen, 1989), we may take the *p*-value obtained here to indicate a good fit. The other statistics in Table 5 also indicate good overall fit, since they meet their critical values by wide margins.

We now discuss the estimated measurement model in Table 6. The standardized coefficients of the indicators of *Perception* are all significant. Moreover, the reliabilities (R^2) are above the recommended level of 0.20 (Jöreskog and Sörbom, 2001), indicating that the three indicators measure *Perception* well. The most reliable indicator is *Percep1*, followed by *Percep2*, and *Percep3*. Apparently, perceptions of the present and past situation, as measured by the first 2 indicators, is more reliable than perception of the future, as expected.

The structural models are presented in Table 7. We first discuss the efficiency sub-models, next the perception sub-model. In line with the conceptual model, *Perception* impacts positively and significantly on *IWAE*. The impact on *IWTE* is positive, though insignificant at conventional levels. These results indicate that farmers with better perception of water scarcity use irrigation water more efficiently. The impact of *Age* is not significant in the *IWTE* and

Table 5
Goodness of fit statistics.

Statistics	χ^2	NFI	GFI	AGFI	RMSEA
Values	34.54(*df* = 28, *p* = 0.1835)	0.926	0.985	0.951	0.026

Note: The cut-off values for NFI, GFI, AGFI and RMSEA indicating a good fit are 0.90, 0.95, 0.90 and 0.06, respectively (Hooper et al., 2008). Put differently, the higher the NFI, GFI and AGFI values and the smaller the RMSEA, the better the fit.

Table 6
The measurement model (standardized coefficients).

Variables	Indicators	Coefficient	*t*-value	R^2
Perception	*Percep1*	0.834	6.682	0.66
	Percep2	0.529	6.174	0.29
	Percep3	0.473	5.826	0.23

IWAE equations although its sign is as expected. This outcome is probably due to the fact that irrigation requires few skills and little farming experience. *Time* has a negative and significant impact on *IWTE* while its negative impact on *IWAE* is insignificant. *Fragmentation* on the other hand reduces *IWAE* at 10% significance level and *IWTE* at 11% significance level. The positive and significant coefficients of *Infrastructure* in the *IWTE* and *IWAE* equations indicate that repaired canals reduce leakage of irrigation water and improve accessibility. *Income* positively and significantly impacts on *IWTE*, and on *IWAE*.

We now turn to the *Perception* sub-model. The impacts of *IWAE* and *IWTE* are negative and significant indicating that efficient farmers perceive water scarcity less as a problem. As postulated in the conceptual model, a likely explanation is that efficient farmers are of the opinion that water scarcity can be reduced by improving efficiency. The impact of *Education* is positive, though insignificant. Apparently, perception of water scarcity does not require much education. The impact of *Income* is negative, though insignificant. The outcome indicates that access to information as facilitated by *Income*, does not play much of a role. *Water price* has a positive and significant impact, indicating that *Water price* is an important signaling mechanism. Finally, *Precipitation* impacts *Perception* negatively and significantly, as assumed.

The non-zero estimates in the Ψ matrix are shown in Table 8. Element ψ_{21} is positive and significant, indicating that the error terms in the *IWTE* and *IWAE* equation are correlated, thus

Table 7
The structural model (standardized coefficients).

Variables	Perception	IWTE	IWAE
IWTE	−0.361[*] (0.202)	——	——
IWAE	−0.568[***] (0.186)	——	——
Perception	——	0.326 (0.246)	0.770[**] (0.360)
Age	——	0.071 (0.064)	0.093 (0.075)
Education	0.036 (0.067)	——	——
Time	——	−0.135[**] (0.065)	−0.104 (0.076)
Fragmentation	——	−0.108 (0.066)	−0.143[*] (0.078)
Infrastructure	——	0.172[**] (0.072)	0.205[**] (0.086)
Income	−0.095 (0.074)	0.145[**] (0.071)	0.162[*] (0.084)
Waterprice	0.179[***] (0.068)	——	——
Precipitation	−0.300[***] (0.070)	——	——
R^2	0.496	0.128	0.385

Note: Standard errors are in parentheses.
[*] $p < 0.10$.
[**] $p < 0.05$.
[***] $p < 0.01$.

Table 8
Estimated Ψ matrix.

Element	Coefficient	t-value	Element	Coefficient	t-value
ψ_{11}	1.182[***]	4.688	ψ_{22}	1.499[***]	3.736
ψ_{21}	0.636[***]	2.459	ψ_{33}	1.000	——

Note:
[*] $p < 0.10$.
[**] $p < 0.05$.
[***] $p < 0.01$.

confirming the use of the SUR structure. Note that ψ_{33} is 1, because the variance of the latent variable *Perception* is fixed at 1 to fix its measurement scale.

Table 9 shows the total effects of all variables on *Perception*, *IWTE* and *IWAE*. The total effect of a variable on an endogenous variable is the sum of its direct effect (in Table 7) and its indirect effects which are its effects on the endogenous variable via intervening endogenous variables.[13] Note that an endogenous variable can have a total effect on itself due to reciprocal or circular paths. The system is stable and the total effects are finite if the stability index is less than 1. For the present case study it is 0.847.

IWAE (−0.365), *IWTE* (−0.232), *Precipitation* (−0.193), *Income* (−0.154) and *Infrastructure* (−0.115) have negative total impacts on *Perception* while it also has a negative effect on itself via various cycles (−0.357). The total effects of −0.232 and −0.365 of *IWTE* and *IWAE* on *Perception* are equal to their anxiety dampening direct effects (−0.361 and −0.568, respectively) plus the anxiety increasing effects that arise via the efficiency increasing impacts of *Perception* itself on each efficiency variable (0.129 and 0.203, respectively). The total effect of *Perception* on itself is the sum of the total effects of the cycles via *IWTE* and *IWAE*. Similarly, the insignificant direct impact of *Income* on *Perception* (−0.095) is

[13] For an overview of the calculation of the total effects of a SEM/LISREL model, see Jöreskog and Sörbom (2001). Particularly, the total effects of the endogenous variables η on themselves are given by equation 1.25 and the total effects of ξ on η by equation 1.26.

Table 9
Estimated total effects (standardized coefficients).

Variables	Perception	IWTE	IWAE
IWTE	−0.232[*] (0.141)	−0.076 (0.087)	−0.179[*] (0.093)
IWAE	−0.365[***] (0.078)	−0.119 (0.074)	−0.281[*] (0.157)
Perception	−0.357[**] (0.150)	0.210 (0.133)	0.495[***] (0.123)
Age	−0.051 (0.037)	0.054 (0.055)	0.055 (0.050)
Education	0.023 (0.043)	0.008 (0.016)	0.018 (0.033)
Income	−0.154[**] (0.064)	0.095[*] (0.053)	0.043 (0.053)
Time	0.069[*] (0.039)	−0.112[**] (0.056)	−0.051 (0.051)
Water price	0.115[**] (0.054)	0.037 (0.027)	0.089[**] (0.038)
Infrastructure	−0.115[***] (0.040)	0.134[**] (0.052)	0.116[**] (0.047)
Fragmentation	0.077[**] (0.037)	−0.082 (0.052)	−0.083[*] (0.046)
Precipitation	−0.193[*] (0.070)	−0.063 (0.042)	−0.149[***] (0.045)

Note: Standard errors are in parentheses.
[*] $p < 0.10$.
[**] $p < 0.05$.
[***] $p < 0.01$.

strengthened by the indirect effects mediated by the two efficiency variables (*IWTE* and *IWAE*). There is no direct effect of *Infrastructure* on *Perception*. However, there is a significant total effect (−0.115) via the mediation of *IWTE* and *IWAE*. *Water price*, *Fragmentation* and *Time* have significant, positive effects of 0.115, 0.077 and 0.069, respectively. The direct effect of *Water price* (0.179), is smaller than its total effect (0.115) because *Perception* has a negative effects on the efficiency variables which feedback on *Perception*. *Fragmentation* and *Time* do not directly affect *Perception*. Therefore, their significant total effects are from indirect effects, i.e. via the intervening endogenous variables *IWAE* and *IWTE*. *Age* has an insignificant total effect on *Perception* because its direct impacts on the efficiency variables are insignificant and there is no direct effect on *Perception*. The total effect of *Education* is also insignificant because its direct impacts on the efficiency variables and on *Perception* are both insignificant.

Infrastructure and *Income* have positive and significant total effects on *IWTE* of 0.134 and 0.095, respectively, which are smaller than their direct effects of 0.172 and 0.145, respectively. The impact reducing effects follow from the negative relationship between *IWTE* and *Perception*. In a similar vein, the negative direct effect of *Time* on *IWTE* (−0.135) is slightly dampened by the *IWTE*–*Perception* interaction effect giving a total effect of −0.112. The total effects of other variables on *IWTE* are insignificant, in line with their direct effects.

The variables with significant positive total effect on *IWAE* are *Perception* (0.495), *Infrastructure* (0.116) and *Water price* (0.089). The positive total effects of the first two variables are smaller than their direct effects because of the negative *Perception*–*IWAE* interaction effects. *Water price* has no direct effect on *IWAE*, thus its total effect equals its indirect effect (0.089) mediated by *Perception*. Similar to *Perception*, *IWAE* has a negative effect on itself because its direct impact on *Perception* is negative while the reverse impact is positive. *IWTE*, *Precipitation* and *Fragmentation* have significant negative total effects on *IWAE* of −0.179, −0.149 and −0.083, respectively. The total effects of *IWTE* and *Precipitation* are indirect via *Perception*. For *Fragmentation*, its total effect on *IWTE* equals its direct effect (−0.143) plus the dampening effect of 0.060 that derives from the effect of *IWAE* on itself.

From the above it follows that most variables in the *Perception–IWTE–IWAE* model are linked in multiple direct and indirect ways. For a full understanding of the impacts of a variable both the direct and the indirect effects have to be taken into account. Focusing on the direct impacts may be misleading because a given direct effect may be strengthened or weakened depending on its indirect links and feedbacks. Insight into the total effects is especially relevant from a policy point of view because it shows which variable has the largest impact on a goal variable. However, for policy design, the possibilities for manipulation also have to be taken into account. For instance, the results in Table 9 show that *Water price* has the largest positive impact on *Perception* which in its turn has the largest positive impact on *IWAE*. Since *Water price* can be easily manipulated, i.e. can be easily changed over time, it is a powerful policy handle to improve *IWAE*. *Infrastructure* on the other hand has the largest impact on *IWTE*. However, it is more difficult to manipulate than *Water price* in that it requires investments which require time to materialize. Judged by their total effects, *Fragmentation* is a much less powerful policy handle than both *Water price* and *Infrastructure*. Moreover, it requires a long term perspective.

Discussion and policy recommendations

Due to reduced precipitation, accelerating industrialization and urbanization, improvement of efficiency of irrigation water use is crucial for sustainable development and food security in the Guanzhong Plain (and other arid regions in China), because irrigation consumes about 60% of total water resources. By simultaneous estimation of a translog production function and its associated cost-minimizing conditions, we obtained farmers' irrigation water technical, allocative and economic efficiency, based on data collected from 347 wheat farmers. In a second stage analysis we examined the determinants of irrigation water technical and allocative efficiencies by means of a structural equation model. The main results are as follows.

Overall economic efficiency is estimated at 0.80 on average, indicating a substantial (cost) saving potential via optimization of water usage and management. Irrigation water technical efficiency is low at 0.35 which indicates a potential for substantial water saving. Improving technical efficiency of irrigation water use could lead to 7% total costs saving. In addition, improvement of allocative efficiency could lead to a further total cost saving of 14%.

The above results clear the way for the introduction of water pricing as a policy handle. As shown in Section "Empirical results", higher water prices improve perception of water scarcity and enhance allocative efficiency. So far the impact of water price on water saving has been very modest. The reason is that the price charged is far below the marginal value. The rationale for sub-optimal prices is income policy. There is a widespread belief among Chinese policy-makers that a higher price for irrigation water is at odds with the objective of narrowing the rural–urban income gap which has been widening substantially over the past decades (Johansson et al., 2002; Tsur et al., 2004). The results obtained in this study show that under current technology, farmers' income losses due to higher water prices can be offset by increasing water use efficiency.

There is another compelling reason for the introduction of 'right' irrigation water prices and improving irrigation water efficiency, viz. long run agriculture sustainability. As mentioned above, water demand in China has been rapidly increasing due to rapid industrialization and urbanization, population growth and dietary shift while the already limited water resources are expected to decrease due to water pollution and climate change. Hence, increasingly less water will be available to the agricultural sector. Higher water prices help reducing dissipation of water which has been prevalent in agricultural production. Furthermore, awareness of irrigation water use efficiency as a prerequisite for agriculture sustainability is likely to (further) contribute to the acceptance of higher water prices. Summarizing, water prices should be revised towards prices that reflects the marginal value of water.

The analysis of the determinants of efficiency reveals that perception has the largest, positive impact on efficiency. Hence, extension is a major policy handle. Tang et al. (2013b) shows that extension should be aimed at social networks. Another reason to focus on extension is that perception sets in motion an iterative process in which perception improves efficiency, but also vice versa: efficient farmers have a more optimistic view of combating water scarcity via improved efficiency.

The results of the paper furthermore confirm the importance of improving irrigation infrastructure at village level. Half of the irrigation canals in China are in a poor state which leads to poor accessibility and substantial loss of irrigation water. However, in spite of the fact that due to canal leakage only 45% of the irrigation water withdrawn reaches the fields, investment in repairing and improving existing aging canals is low on the political agenda. On the other hand, investment in new, prestigious projects like dams, reservoirs, and water transfer projects is substantial. Particularly, the latter accounts for 77% of total annual water-project investments while the figure for rehabilitation of existing projects is 20% only (China Water Statistical Yearbook, 2012). What's more, half of world's dams are in China already and are sufficient for existing and future demand (Liu et al., 2013). Rehabilitation and improving the existing village-level irrigation infrastructure and reduction of agricultural water demand so that more water becomes available for households, industry and ecological purposes is far more economical than investing in prestigious new projects. (Note that such projects would not only improve farmer technical efficiency, but also canal-wide efficiency.)

We also found evidence in this paper that land fragmentation decreases efficiency. After the introduction of Household Responsibility System in 1978, collectively managed land was allocated to individual farmers. Implementation of the policy brought with it the division of plots homogenous in amongst others soil type or irrigation accessibility, into several plots such that each household was allocated at least one plot of a certain kind. This led to irregularly shaped and spatially dispersed plots which increased irrigation time and made it difficult to apply water-saving techniques. The decline of the frequency and magnitude of land reallocation after the introduction of the "Rural Land Contract Law" in 2002 has not been enough to reverse the situation (Wang et al., 2011). Instead, a land rental market is needed at which farmers are allowed to freely trade their user rights. This institutional change would contribute to achieving land consolidation and thus higher water use efficiency, especially in an era when off-farm employment is rapidly developing. As a first step, integrated management of fields could be encouraged to facilitate the introduction of improved irrigation technology such as tubes which would reduce seepage during transportation, particularly to distant plots. It would also reduce labor input into irrigation and thus reduce low efficiency due to part time farming.

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A Visualization Review of Cloud Computing Algorithms in the Last Decade

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Abstract: Cloud computing has competitive advantages—such as on-demand self-service, rapid computing, cost reduction, and almost unlimited storage—that have attracted extensive attention from both academia and industry in recent years. Some review works have been reported to summarize extant studies related to cloud computing, but few analyze these studies based on the citations. Co-citation analysis can provide scholars a strong support to identify the intellectual bases and leading edges of a specific field. In addition, advanced algorithms, which can directly affect the availability, efficiency, and security of cloud computing, are the key to conducting computing across various clouds. Motivated by these observations, we conduct a specific visualization review of the studies related to cloud computing algorithms using one mainstream co-citation analysis tool—CiteSpace. The visualization results detect the most influential studies, journals, countries, institutions, and authors on cloud computing algorithms and reveal the intellectual bases and focuses of cloud computing algorithms in the literature, providing guidance for interested researchers to make further studies on cloud computing algorithms.

1. Introduction

In cloud computing environments, users can share computing resources and data located all over the world, as if obscured by a cloud. The cloud computing scheme has competitive advantages such as on-demand self-service, rapid computing and elasticity, cost reduction, almost unlimited storage, device and location independence, and environmental friendliness [1–4], so it has received extensive attention from both academia and industry in recent years.

Cloud computing has prevailed in the literature for about 10 years, and plenty of related works have been presented. To summarize the extant studies and find potential research directions, some review works related to cloud computing have been consecutively reported [5–15]. Readers can refer to the review works in Section 2.2 for details.

In the literature, various aspects on cloud computing have been reported, such as service availability [5,6,16], computing schemes and algorithms [17,18], data security [10–12,19], and energy management [9,20]. Among these aspects, advanced algorithms are the key to conducting the computing across various clouds, which have drawn special attention. Thus, our research goal in this work is to make a specific visualization review of the studies related to cloud computing algorithms.

The above-mentioned review works have summarized extant studies related to cloud computing and observed enlightening insights to help interested researchers, but few analyze these studies based on the citations. The times cited of one paper represent the influence of the paper, so co-citation analysis is an effective way to measure the impact of studies, journals, countries, institutions, and authors in the development of one specific research area [21]. Meanwhile, it can provide scholars a strong support to identify the intellectual bases and leading edges of a specific field. Motivated by these observations, we conduct a specific visualization review of the extant studies related to cloud computing algorithms using one mainstream co-citation analysis tool—CiteSpace. The main contributions of the work include: (i) The most influential studies and journals on cloud computing algorithms from 2006 to 2015 are identified, providing guidance for interested researchers to make further studies; (ii) From the country and institution visualization, we find the research development path of cloud computing algorithms and identify the current hot regions; (iii) From the author visualization, we detect the most influential authors focusing on cloud computing algorithms; (iv) Thirty keywords are identified to reveal the intellectual bases and focuses of cloud computing algorithms in the literature.

The work is organized as follows. In Section 2, we present a brief summary on extant definitions and review works on cloud computing. In Section 3, we introduce our review methodology, including the data collection process and visualization review tool. In Section 4, we present visualization results from seven aspects: cited references, cited journals, countries, institutions, authors, keywords, and categories. Section 5 concludes the review work.

2. Related Studies

This section introduces some definitions of cloud computing in the literature and presents a brief summarization on extant review works related to cloud computing.

2.1. The Origin and Definition of Cloud Computing

As stated by Prof. Regalado [22], the origin of cloud computing is not clear. In the literature, the term of cloud computing was early used in a 1996 Compaq business plan [22]. The concept suddenly became a hot term after the usage of Amazon and Google in around 2006, and drew extensive attention in the following years, as Figure 1 shows. Obviously, the popularity of cloud computing will last a long time, because both Big Data and Internet of Things will need the support of a matched computing scheme.
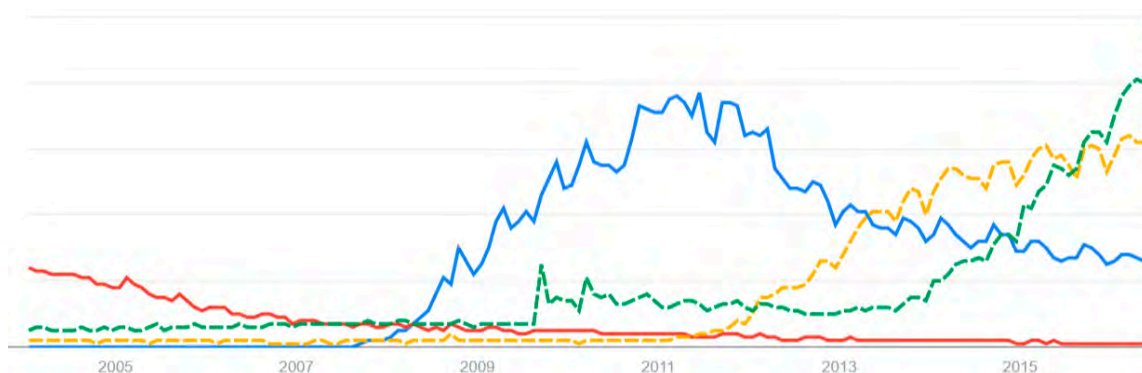
Figure 1. Cloud computing related terms in Google trends (**Red**: Grid Computing; **Blue**: Cloud Computing; **Yellow**: Big Data; **Green**: Internet of Things).

Although the term of cloud computing is recognized just for about 10 years, the literature has reported plenty of versions on its definition. Geelan [23] summarized the definitions of cloud computing from 21 experts. In the summarization, some original definitions of cloud computing were discussed and identified. For example, Cohen defined the cloud computing as "one of those

catch all buzz words that tries to encompass a variety of aspects ranging from deployment, load balancing, provisioning, business model and architecture" [23]. Readers can refer to the report for other statements on cloud computing. However, none of them presents a comprehensive and well recognized definition.

Then, Vaquero et al. [24] presented a cloud definition: "Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services)", and analyzed the differences of the cloud approaches from the grid approaches. Wang et al. [25] gave a definition of computing cloud as "a set of network enabled services, providing scalable, QoS guaranteed, normally personalized, inexpensive computing infrastructures on demand, which could be accessed in a simple and pervasive way". Armbrust et al. [8] stated that "cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services". These studies not only formulated definitions of cloud or cloud computing, but also identified the specific characteristics and functionalities of cloud computing, such as user-centric interfaces, on-demand service provisioning, and virtualization.

Later on, Mell and Grance, from the National Institute of Standards and Technology (NIST), formulated a definition of cloud computing [26]: "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". They also specified the definition using five characteristics, three service models, and four deployment models. This definition has attained wide recognition from both academia and industry, and can be taken as a standard definition of cloud computing.

In Section 2.2, we also summarize other definitions of cloud computing.

2.2. Review Works Related to Cloud Computing

In the literature, plenty of review works on cloud computing have been reported, as Tables 1 and 2 show. These review works can be divided into two categories: general reviews and specific reviews.

In Table 1, we summarize five general review works on cloud computing and highlight the issues needed to be solved in the development of cloud computing. Besides, other meaningful analyses are also presented, as stated below. Vouk [5] discussed the concept of cloud computing from the aspects of service-oriented architecture, components, workflows, virtualization, and users. Armbrust et al. [6,8] analyzed the in-depth drives of the coming of cloud computing, and proposed the top 10 obstacles and opportunities for cloud computing. Kim [7] listed several concerns in the adoption of cloud computing such as availability, security and privacy, interoperability, and compliance. Zhang et al. [9] formulated a layered model of cloud computing and analyzed its business model.

From the presented issues in Table 1, we can get the following observations:

(1) The computing across different clouds is one basic open issue in the development of cloud computing, which is reflected in the terms such as service construction among clouds, cloud metadata management, image portability and formation, collaboration applications, application and data integration across clouds, server consolidation, multimedia transmission and data mining, and virtual machine migration.

(2) Advanced service and software platforms are in urgently needed in order to deal with issues such as cloud computing software platforms, software frameworks, novel cloud architectures, service availability, automated service provisioning, service management, scalable storage, storage technologies, and data management.

(3) Security is one of the key concerns, which is reflected in the presented issues such as security, data lock-in, data confidentiality and auditability, data transfer bottlenecks, bugs in large-scale distributed systems, and data security.

Table 1. General reviews on cloud computing.

Concepts of Cloud Computing		Issues Needed to Be Solved	
Vouk [5]	... embraces cyberinfrastructure, and builds upon... research in virtualization, distributed computing, "grid computing", utility computing, and, more recently, networking, Web and software services.	(1) (2) (3) (4) (5)	Service construction among clouds Cloud metadata management Optimization of loading times Image portability and formation Security
Armbrust et al. [6,8]	... refers to both the applications delivered as services over the Internet and the hardware and systems software in the datalefts...	(1) (2) (3) (4) (5) (6) (7) (8) (9) (10)	Service availability Data lock-in Data confidentiality and auditability Data transfer bottlenecks Performance unpredictability Scalable storage Bugs in large-scale distributed systems Quick scaling Reputation fate sharing Software licensing
Kim [7]	... being able to access files, data, programs and third party services from a Web browser via the Internet that are hosted by a third party provider.	(1) (2) (3) (4) (5)	Cloud computing software platform Collaboration applications Application and data integration across clouds Multimedia transmission and data mining Service management
Zhang et al. [9]	... a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.	(1) (2) (3) (4) (5) (6) (7) (8) (9)	Automated service provisioning Virtual machine migration Server consolidation Energy management Traffic management and analysis Data security Software frameworks Storage technologies and data management Novel cloud architectures

Table 2. Specific reviews on the security of cloud computing.

Concept of Cloud Computing		Security Issues	
Hu et al. [10]	... a conglomerate of several different computing technologies and concepts like grid computing, virtualization, autonomic computing, service oriented architecture, peer-to-peer computing, and ubiquitous computing.	(1) (2) (3) (4) (5) (6) (7) (8) (9)	Encryption-on-demand Trusted virtual data left implementation Trusted cloud computing Privacy model Intrusion detection strategy Dirichlet reputation model Anonymous bonus point system Network slicing Privacy
Subashini and Kavitha [11]	... a style of computing where massively scalable IT enabled capabilities are delivered "as a service" to external customers using Internet technologies.	(1) (2) (3) (4)	Security related to third party resources Application security Data transmission security Data storage security
Khorshed et al. [12]	... is a system, where the resources of a data left are shared using virtualization technology, which also provide elastic, on demand and instant services to its customers and charges customer usage as utility bill.	(1) (2) (3) (4) (5) (6) (7)	Abuse and nefarious use of cloud computing Insecure application programming interfaces Malicious insiders Shared technology vulnerabilities Data loss/leakage Account, service and traffic hijacking Unknown risk profile

Extensive related studies on the security of cloud computing have been reported [27]. Several specific review works on the security are summarized in Table 2. In addition, there are some other specific reviews related to cloud computing. Dinh et al. [13] argued that mobile cloud computing (MCC) could bring new types of services and facilities for mobile users to take full advantage of cloud computing, and they also analyzed the architectures, advantages, and applications of MCC. Jula et al. [14] thought that service composition was the key to conduct cloud computing over clouds, and presented a specific review on cloud computing service composition. Hashem et al. [15] reviewed the rise of big data in cloud computing, and discussed the relationship between big data and cloud computing, big data storage systems, and so on.

3. Methodology

3.1. Data Collection

For a review work, it is important to collect and analyze related studies in a proper way. In this work, we collected related studies on cloud computing algorithms in Web of Science (WoS). WoS includes extensive citation databases such as Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, Conference Proceedings Citation Index—Science, Conference Proceedings Citation Index—Social Science & Humanities, and recent Emerging Sources Citation Index. Thus, it is a good choice to use WoS to collect related studies and their citation relations.

Specific steps of collecting studies related to cloud computing algorithms in the work are as follows: (1) Open the WoS search website: https://apps.webofknowledge.com/; (2) Select the Web of Science Core Collection and conduct the advanced search with the setting: TS = (Cloud* and Comput* and algorithm*) NOT WC = (Astronomy & Astrophysics or Meteorology & Atmospheric Sciences or Optics or Geoscience or Geography), where TS denotes the topic of the studies (TS consists of Title, Abstract, Keywords, and Keywords Plus which is the result of Thomson Reuters editorial expertise in Science [28]), WC denotes Web of Science Category [28] (Here we use WC to exclude the records dealing with the real cloud using some algorithms), and * denotes any other texts; (3) The language, document type, and timespan are set as "English", "article", and "2006–2015", respectively. Using the above setting, we retrieved 1865 records and then manually deleted 32 records which are not related to cloud computing, and downloaded the full records and cited references of the remaining 1833 studies. The full records and cited references were saved in the text format for the requirement of the visualization tool—CiteSpace.

3.2. Visualization Tool

Author co-citation analysis (ACA)—originally introduced by White and Griffith [29]—is an effective method to identify and visualize the intellectual structure of one specific research field [30]. Citation frequency is the main basis of existing ACA tools. By analyzing the co-citations among related studies, the intellectual bases, research fronts, and development trends in the field can be identified. Thus, the visualization of co-citations is helpful for researchers to conduct further studies.

CiteSpace, one of the mainstream ACA tools, was initially developed by Chaomei Chen in 2004 [31,32], and is lastly updated by Chen's research team. The latest version is CiteSpace 5.0.R1 SE, available at http://cluster.ischool.drexel.edu/~cchen/citespace/download/ [33]. The principle of CiteSpace is based on co-citation analysis theory and pathfinder network scaling algorithms, so CiteSpace can detect the development paths and trends of one specific subject. Intellectual turning points play key roles in the development and formulation of scientific domains. By identifying these turning points, CiteSpace can find the development path of one subject, which is beneficial for researchers to understand the subject and catch research fronts.

In this work, we use the latest version of CiteSpace, that is, 5.0.R1 SE. Before installing CiteSpace, we equipped our computer with Java Runtime (JRE) 8.0. With 1833 full records on cloud computing algorithms, we present the visualization results in the following section.

4. Visualization Results

CiteSpace includes 11 visualization functions by analyzing different terms such as author, institution, country, term, keyword, category, cited reference, cited author, and cited journal. In this work, we make co-citation visualization, cooperation visualization, and co-occurrence visualization by analyzing cited reference, cited journal, country, institution, author, keyword, and category.

4.1. Cited Reference Visualization

Cited reference is one key aspect of co-citation visualization, which can identify the most influential studies of one specific research domain. The time slicing is from 2006 to 2015, and the year per slice is set as 1. The node type is selected as cited reference, and the strength among links is measured by the Cosine metric:

$$\text{Cosine}(x, y) = \frac{C_x C_y}{||C_x|| \, ||C_y||}$$

where $C_x C_y$ represents the co-citation counts between paper x and paper y, and $||C_x||$ and $||C_y||$ represent the times cited of paper x and paper y, respectively.

Filtering strategy is another key setting for the co-citation analysis. In this work, we use the most common strategy, that is, Top N strategy. This filtering strategy selects out top N records in terms of citation frequencies during the slice. Considering the number of our records, we take N as 100, that is, 100 records are selected in each slice. After 2104 iterations, the cited reference visualization is obtained, as Figure 2 shows. In Figure 2, the seven most influential studies on cloud computing or their algorithms from 2006 to 2015 are identified (Here the threshold of times cited is set as 30).
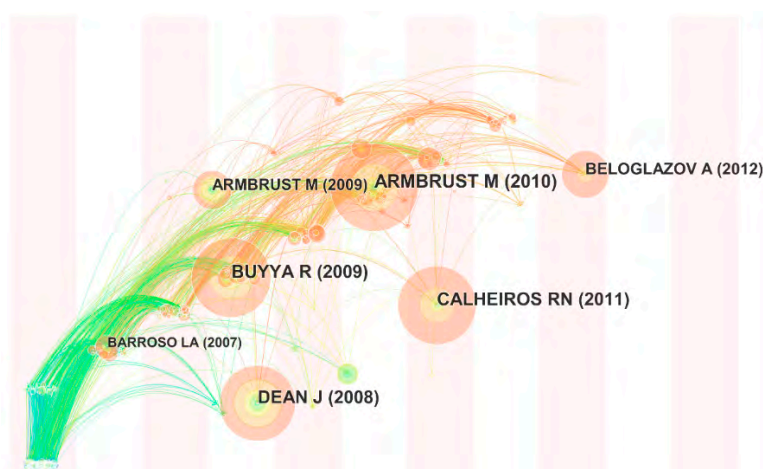
Figure 2. Cited reference visualization.

The study entitled "A View of Cloud Computing" by M. Armbrust et al. in 2010 [8] has the most citation frequency. This study was published on a top journal in the computer area, that is, Communications of the ACM. In this review, authors argued that confusion existed in the popularity of cloud computing, and proposed 10 obstacles and opportunities for cloud computing. As we can see, another most influential work is also from Armbrust's team at University of California, Berkeley, that is, "Above the Clouds: A Berkeley View of Cloud Computing" [6]. Besides listing the obstacles and opportunities, this report also analyzed the reasons of the emergence of cloud computing and presented observations about cloud computing economic models. As we can see, these two works belong to qualitative analysis studies with no models or algorithms, but really present enlightening insights for further studies. Although these qualitative works did not present specific algorithms,

they indeed have influenced studies related to cloud computing greatly, at least observed by citation relationships among the 1833 records.

Among the most influential studies, two specific algorithms or tools on cloud computing were observed, that is, MapReduce and CloudSim. Dean and Ghemawat [17], from Google Inc. (Mountain View, CA, USA), presented the work "MapReduce: Simplified Data Processing on Large Clusters" which introduced the programming model, basic implementation modules, and extensive functions of MapReduce. Calheiros et al. [18], from the Cloud Computing and Distributed Systems (CLOUDS) Laboratory at the University of Melbourne, reported a toolkit for the modeling and simulation of cloud computing environments—CloudSim, from the architecture, design, and implementation. Actually, the same research team chaired by Prof. Buyya had presented a toolkit for modeling and simulating of grid computing environments, namely, GridSim [34]. Another two identified influential works are also from Prof. Buyya's team, that is, "Cloud Computing and Emerging IT Platforms: Vision, Hype, and Reality for Delivering Computing as the Fifth Utility" [35] and "Energy-Aware Resource Allocation Heuristics for Efficient Management of Data Centers for Cloud Computing" [36]. Both studies were published in the journal—Future Generation Computer Systems.

As we can see, the above most influential works include two overview papers besides four specific contributions to cloud computing algorithms. In order to find out why the overview papers have a profound influence, we check cited articles of the overview paper "A View of Cloud Computing", and find out two main underlying reasons. One is that scholars need a strong and significant motivation to develop their cloud computing algorithms. For example, Calheiros et al. [18] cited the overview paper in say that "the importance of these services was highlighted in a recent report from the University of Berkeley as: cloud computing, the long-held dream of computing as a utility has the potential to transform a large part of the IT industry, making software even more attractive as a service". The other is that interested researchers want to find out what on earth "cloud computing" is before presenting suitable algorithms. Armbrust et al. [8] presented a definition of cloud computing with clear descriptions of the differences between cloud computing and other similar terms such as software as a service (SaaS) and grid computing. In addition, another important reason why so many researchers cite the Armbrust et al.' s overview paper is that the cited work is published in one top journal (i.e., Communications of the ACM) by one famous scholar from one prestigious institution (i.e., the University of Berkeley).

The last identified influential work is reported by Barroso and Hölzle from Google Inc. [37]. Barroso and Hölzle argued that energy management should be a key issue for servers and data center operations, focusing on the reduction of both economic costs and environmental impacts. Interestingly, no cloud or grid related terms were mentioned in the work. After checking some studies citing the work, the term of energy proportionality proposed in the work takes the attention of the popularity, because energy saving is recognized as one important performance indicator of cloud computing algorithms. The cloud computing scheme deals with large amounts of data, management and switching of communications, producing incomprehensibly huge energy consumption. Thus, in order to implement the energy proportionality, wide attention has been paid to develop energy-saving algorithms to improve the energy usage profile of every component in cloud computing systems.

4.2. Cited Journal Visualization

Cited journal is another aspect of co-citation visualization. Using the same setting with those in Section 4.1, we can get the cited journal visualization by selecting the node type as cited journal. After 736 iterations, the cited journal visualization was obtained, as Figure 3 and Table 3 show (Here the threshold of citation frequency is set as 150).
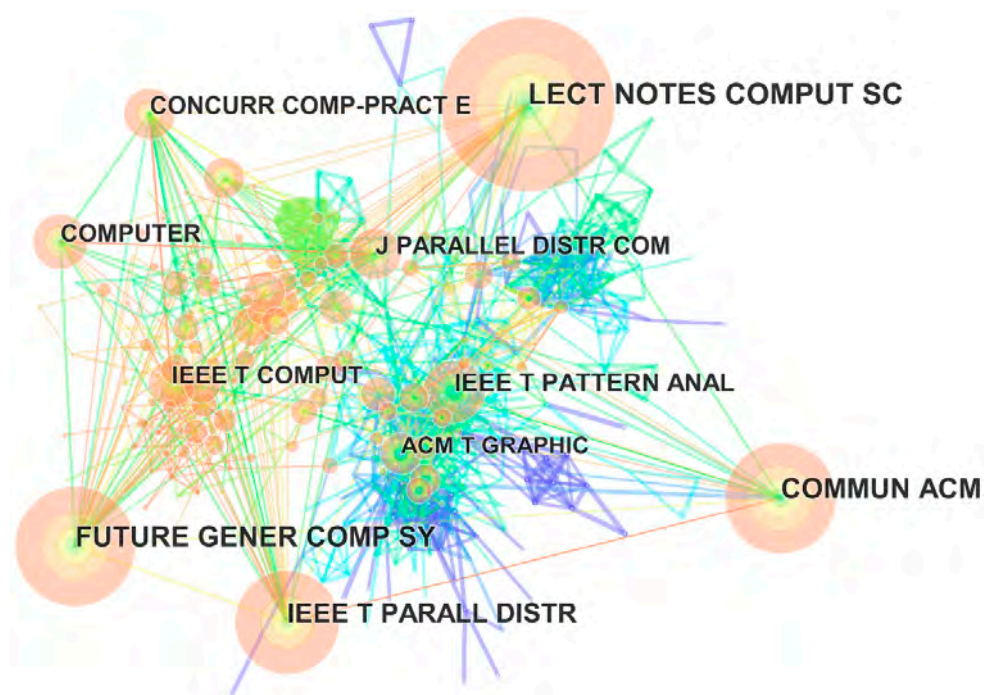
Figure 3. Cited journal visualization.

Table 3. The identified journals.

Full Journal Names	Abbreviated Journal Names	Citation Frequency	Publishers
Lecture Notes in Computer Science	LECT NOTES COMPUT SC	573	Springer
Future Generation Computer Systems	FUTURE GENER COMP SY	391	Elsevier
Communications of the ACM	COMMUN ACM	377	Association for Computing Machinery
IEEE Transactions on Parallel and Distributed Systems	IEEE T PARALL DISTR	337	IEEE
IEEE Transactions on Pattern Analysis and Machine Intelligence	IEEE T PATTERN ANAL	228	IEEE
Computer	COMPUTER	182	IEEE
Journal of Parallel and Distributed Computing	J PARALLEL DISTR COM	177	Elsevier
Concurrency and Computation: Practice and Experience	CONCURR COMP-PRACT E	175	John Wiley & Sons
IEEE Transactions on Computers	IEEE T COMPUT	169	IEEE
ACM Transactions on Graphics	ACM T GRAPHIC	156	Association for Computing Machinery

As Table 3 shows, the top five journals are Lecture Notes in Computer Science, Future Generation Computer Systems, Communications of the ACM, IEEE Transactions on Parallel and Distributed Systems, and IEEE Transactions on Pattern Analysis and Machine Intelligence. Lecture Notes in Computer Science ranks top on the list, mostly because it is a series book focusing on frequently publishing new developments in computer science and information technology research. Two of the above five journals, that is, Future Generation Computer Systems and Communications of the ACM, reported the most influential studies identified in Section 4.1. This reveals the important role of key studies in improving the position of academic journals. Note that several meteorological journals are identified mainly because some studies on dealing with real clouds are included in the records.

In the aspect of publishers, IEEE contributes the highest citations, with a total of 916 times recorded in Table 3, which shows the dominant position of IEEE in the area of cloud computing. Springer, Elsevier, and Association for Computing Machinery follow the list, with comparative impacts. From the journal visualization, publishers can recognize the contribution of their journals to the field of cloud computing, and make proper publishing policies to enhance their positions in the development of cloud computing research. For interested researchers, the results in Figure 3 and Table 3 are helpful for them to catch mainstream academic journals on cloud computing algorithms. To sum up, the visualization of cited journals provides supports for both publishers and researchers to make their research decisions, which is finally favorable to the academic development and practical application of cloud computing algorithms.

4.3. Country and Institution Visualization

Country is one important aspect of cooperation visualization. By choosing the node type as country, we got the country visualization of the 1833 studies on cloud computing algorithms after 41 iterations, as Figure 4 shows. In Figure 4, the threshold of citation frequency is 30, that is, all the countries with more than 30 citations are labeled out. We also label out the hot periods of these countries using different colors, as the top bar in Figure 4 shows.
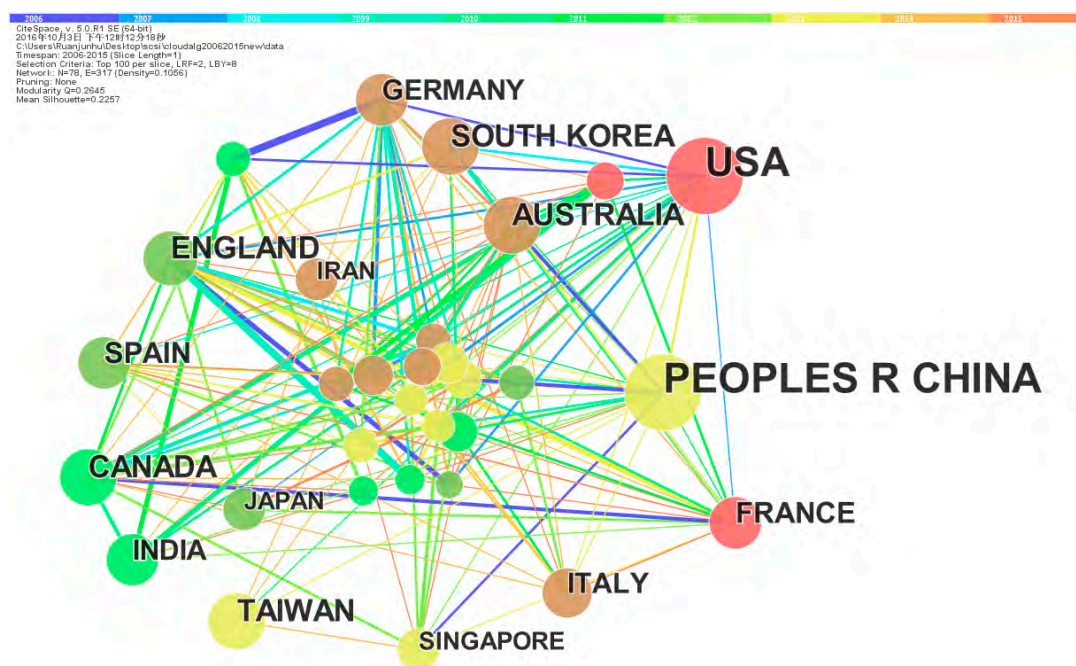
Figure 4. Country visualization.

Based on the citations, China, USA, Taiwan, Australia, Canada, South Korea, England, France and then other countries or regions make decreasing contributions to the intellectual bases of cloud computing algorithms. Meanwhile, these countries have different hot periods. Canada, Japan, England, India, and Spain focused on the cloud computing algorithms at an earlier stage, mainly before 2012; China, Taiwan, and Singapore were the next followers, mainly during from 2013; Then, the research attention was extended to more countries including Germany, South Korea, Australia, Italy, France, and USA. The contribution of one country on the research has a positive relation with the supporting funds. As Table 4 shows, the correlation coefficient between identified citation frequency and gross expenditure on R & D is about 0.93. For simplicity, we just use the 2014 GERD summarized by the Industrial Research Institute [38].

Table 4. The correlation of identified citation frequency and gross expenditure on R & D (GERD).

Countries or Regions	Citation Frequency	2014 GERD (Billion US $)
China	591	485.39
USA	503	343.78
Taiwan	107	24.02
Australia	103	24.75
Canada	102	30
South Korea	99	64.3
England	91	44.07
France	79	58.21
Spain	75	19.18
Germany	72	103.2
India	71	61.85
Italy	63	24.79
Japan	35	163.44
Iran	35	10.79
Singapore	35	11.8
Correlation coefficient	**0.93**	

From the country visualization, we can find the development path of cloud computing algorithms and identify the current hot areas. Meanwhile, the research connections among countries can also be detected. For example, Canada and France have close academic cooperation on cloud computing algorithms. The formulation of these academic connections is mainly due to the exchange and cooperation among related institutions.

Behind the countries, research and application institutions have a specific impact on the development of cloud computing algorithms. In order to reveal which institutions make influential contributions to cloud computing algorithms, we also conducted the institution visualization. By choosing the node type as institution, we got the institution visualization of 1833 studies after 2321 iterations, as Figure 5 and Table 5 show (The threshold of citation frequency is 15).
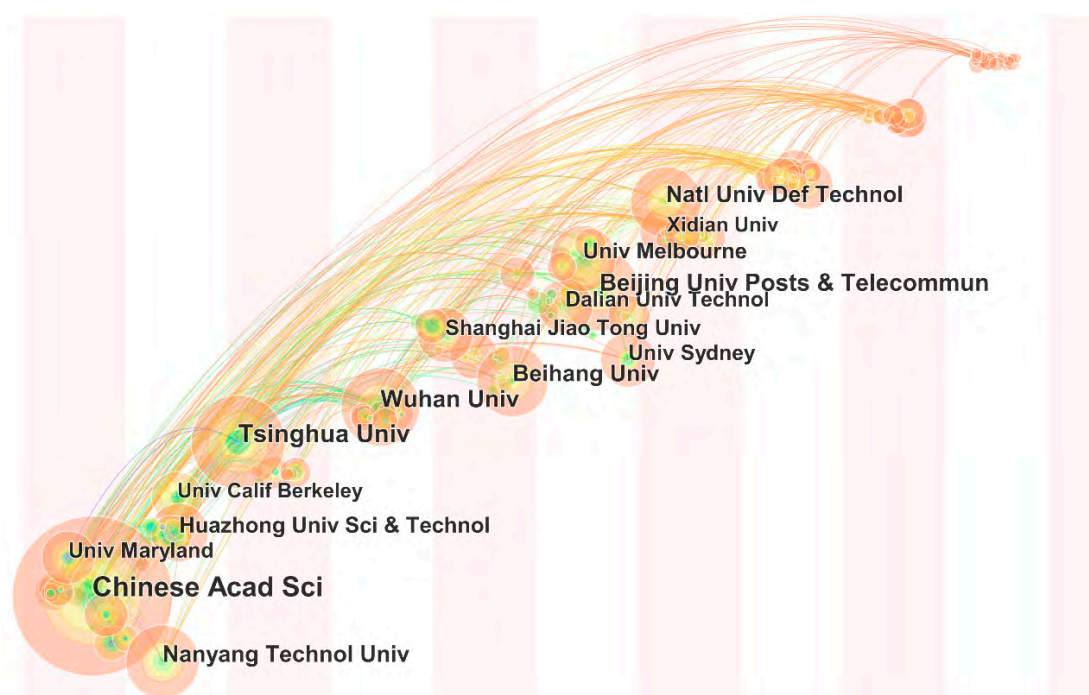
Figure 5. Institution visualization.

Table 5. The identified institutions.

Full Institution Names	Abbreviated Institution Names	Citation Frequency	Countries
Chinese Academy of Sciences	Chinese Acad Sci	49	China
Tsinghua University	Tsinghua Univ	29	China
Wuhan University	Wuhan Univ	25	China
Beijing University of Posts and Telecommunications	Beijing Univ Posts & Telecommun	25	China
Nanyang Technological University	Nanyang Technol Univ	23	Singapore
Beihang University	Beihang Univ	23	China
National University of Defense Technology	Natl Univ Def Technol	22	China
University of Melbourne	Univ Melbourne	20	Australia
Huazhong University of Science & Technology	Huazhong Univ Sci & Technol	19	China
University of Maryland	Univ Maryland	17	USA
The University of Sydney	Univ Sydney	17	Australia
Dalian University of Technology	Dalian Univ Technol	17	China
Shanghai Jiao Tong University	Shanghai Jiao Tong Univ	17	China
University of California, Berkeley	Univ Calif Berkeley	16	USA
Xidian University	Xidian Univ	16	China
University of Electronic Science and Technology of China	Univ Elect Sci & Technol China	15	China
Zhejiang University	Zhejiang Univ	15	China
Nanjing University	Nanjing Univ	15	China
South China University of Technology	S China Univ Technol	15	China

As Figure 5 and Table 5 show, the most influential institutions focusing on cloud computing algorithms are mainly from China, USA, Australia, and Singapore. The top five Chinese institutions are Chinese Academy of Sciences, Tsinghua University, Wuhan University, Beijing University of Posts and Telecommunications, and Beihang University. The top American institutions are University of Maryland and University of California at Berkeley. The top Australian institutions are University of Melbourne and The University of Sydney.

As we can see, the institution visualization result is consistent with the cited reference visualization and country visualization. Two institutions which produce five of the most influential studies, that is, University of California at Berkeley and University of Melbourne, are detected.

4.4. Author Visualization

By selecting the node type as author, we got the author visualization of the 1833 studies, as Figure 6 shows (The citation frequency threshold is set as 50). Based on the author visualization, we can find the most influential researchers on cloud computing algorithms.
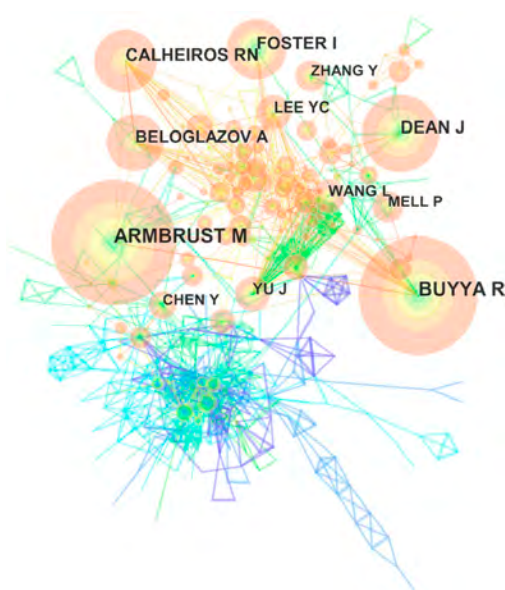
Figure 6. Author visualization.

　　　Michael Armbrust ranks on the top of the list. He is from University of California, Berkeley. As we observed above, Prof. Armbrust's two overview papers [6,8] have been highly cited, so here he is identified. However, he does not present specific contributions on cloud computing algorithms. Prof. Rajkumar Buyya, from University of Melbourne, ranks the second. Actually, several of Prof. Buyya's cooperators are also identified as the most influential scholars on cloud computing algorithms, such as Rodrigo N. Calheiros, Anton Beloglazov, and Young Choon Lee, respectively working at University of Melbourne, IBM Research-Australia, and Macquarie University. Jeff Dean, from Google Inc., ranks the third. As stated in Section 4.1, all the above scholars have been identified as contributors of the most influential studies. This consistency reveals the impact of key studies on the position of one scholar.

　　　Ian T. Foster, working at University of Chicago, is another influential scholar focusing on cloud computing algorithms. Prof. Foster had focused on grid computing before he got involved in cloud computing. The top record on cloud computing from Prof. Foster is "Cloud Computing and Grid Computing 360-Degree Compared" [39]. This work presented a side-by-side comparison between cloud computing and grid computing from various angles such as business model, architecture, resource management, programming model, application model, and security model.

　　　Peter Mell, who is from the National Institute of Standards and Technology and gave a standard definition of cloud computing together with T. Grance [26], is also identified on the list. As mentioned above, the visualization results by CiteSpace are based on the citation relationships among the used records. Peter Mell is detected out because enough studies on cloud computing algorithms have cited his work, although the NIST definition by P. Mell and T. Grance does not focus on algorithms.

　　　Four Chinese scholars formulate another group of influential researchers on cloud computing algorithms: Jian Yu, Lizhe Wang, Yinqian Zhang, and Yu Chen, who are now working at Auckland University of Technology, The Chinese Academy of Sciences, Ohio State University, and Binghamton University, respectively.

4.5. Keyword and Category Visualization

　　　The keyword term can be used to cluster intellectual bases and find research directions. After 2521 iterations, 29 keywords were identified (The citation frequency threshold is set as 30), as Figure 7 shows.
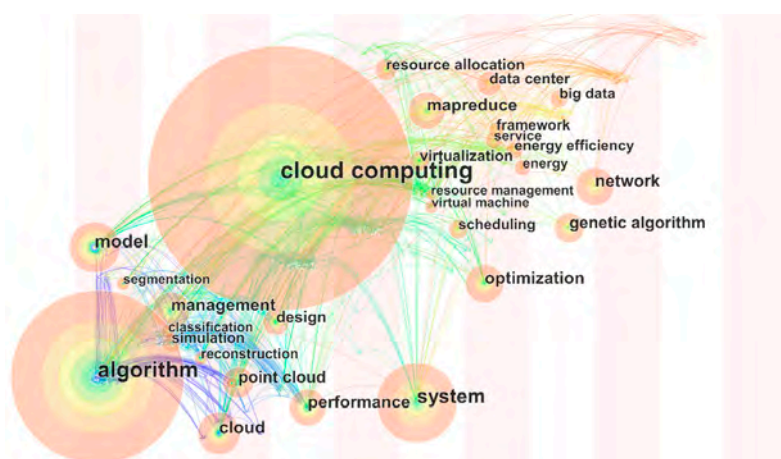
Figure 7. Keyword visualization.

　　　These 29 keywords can be divided into four categories:

(1)　　Cloud computing and its characteristics

　　　The identified keywords in this category include cloud computing, cloud, virtual machine, point cloud, virtualization, and big data. Obviously, this category takes the biggest proportion in

the identified keywords, since almost every study in the records will place the "cloud" or "cloud computing" into the keywords list. It is worth noting that only the virtualization and big data among the characteristics of cloud computing are identified. This, to some extent, shows the most remarkable characteristics of cloud computing.

(2)   Cloud algorithms

The identified keywords in this category include algorithm, MapReduce, and Genetic Algorithm. The algorithm keyword ranks the second on the list, which reveals that designing suitable algorithms is the key to implementing cloud computing. Among the exiting algorithms, two specific algorithms—that is, MapReduce and Genetic Algorithm—are detected. This observation can provide a guidance for researchers focusing on the development and application of cloud computing algorithms.

(3)   Cloud issues

The cloud issues refer to the considered problems in the literature related to cloud computing. General keywords in this category include model, system, network, framework, management, design, optimization, classification, simulation, computation, and service. Specific keywords include resource allocation, resource management, scheduling, segmentation, reconstruction, and data center. These keywords can provide some research directions for interested scholars on cloud computing.

(4)   Cloud computing performance

The keywords in this category include performance, energy, and energy efficiency. As stated by Khanghahi and Ravanmehr [40], nowadays the term "performance" includes more extensive concepts such as reliability, energy efficiency, and scalability. Khanghahi and Ravanmehr [40] also listed some specific cloud computing performance indicators such as average response time per unit time, network capacity per second, average waiting time per unit time, and percentage of CPU utilization. Nevertheless, only the energy efficiency is detected in our work, which reveals that more and more attention is paid to energy saving and environmental friendliness in the research of cloud computing algorithms, as stated by Tseng et al. [20].

In addition, we also got the category visualization to show the contribution of various subjects, as Figure 8 shows (The citation frequency threshold is 60). The top five subjects are Computer Science, Engineering, Computer Science-Theory & Methods, Engineering-Electrical & Electronic, and Computer Science-Software Engineering.
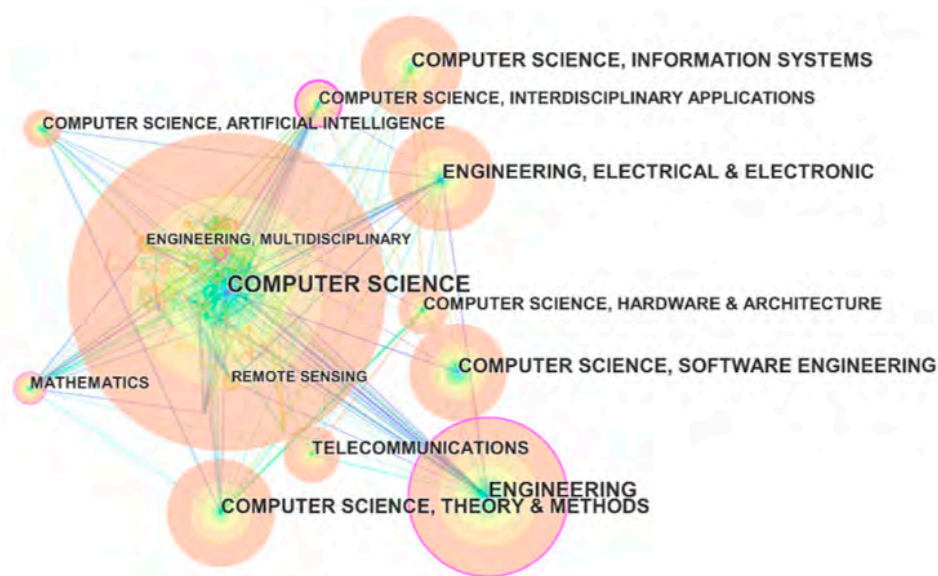
Figure 8. Category visualization.

5. Conclusions

In this work, we collected 1833 records on cloud computing algorithms from Web of Science, and conducted a visualization review on these studies using one mainstream co-citation analysis tool—CiteSpace. From the visualization results, we got some enlightening observations for supporting interested researchers to make further studies on cloud computing:

(1) The most influential studies as well as two specific algorithms (namely, MapReduce and CloudSim) on cloud computing are identified by the work, which are contributed by Armbrust's team at University of California, Berkeley; Buyya's team at the University of Melbourne; and Google Inc. Besides some specific contributions, overview papers can also have an underlying profound influence on the motivation and significance of the studies related to cloud computing.

(2) The top five journals in terms of the contribution to cloud computing algorithms are Lecture Notes in Computer Science, Future Generation Computer Systems, Communications of the ACM, IEEE Transactions on Parallel and Distributed Systems, and IEEE Transactions on Pattern Analysis and Machine Intelligence. Two of the above five journals, that is, Future Generation Computer Systems and Communications of the ACM, reported the most influential studies. Thus, the key studies with high citations take an important role in improving the position of academic journals.

(3) China, USA, Taiwan, Australia, Canada, South Korea, England, France, and then other countries or regions make decreasing contributions to the intellectual bases of cloud computing algorithms. However, these countries have different hot periods. The contribution of one country to the research in one specific field has a positive relationship with its amount of supporting funds, and publications with high citations in one institution can help to improve the position of the institution.

(4) Author visualization finds the most influential authors on cloud computing, including Prof. Buyya from the University of Melbourne as well as his team members; Prof. Armbrust from University of California, Berkeley; Jeff Dean from the Google Inc.; Prof. Foster from University of Chicago; Peter Mell from The National Institute of Standards and Technology; and four Chinese scholars: Jian Yu, Lizhe Wang, Yinqian Zhang, and Yu Chen.

(5) Twenty-nine keywords are identified to reveal the intellectual bases and focuses of cloud computing algorithms in the literature, and the mainstream subjects focusing on cloud computing algorithms are also detected. The emerging intellectual foci from the literature related to cloud computing consist of four aspects: cloud computing and its characteristics, cloud algorithms, cloud issues, and cloud computing performance.

Although the view has observed visual insights related to cloud computing algorithms in last decade, some deficiencies—which are difficult to avoid—still exist. For example, we cannot make sure all the valid records have been collected, and some intrinsic causes still need further analysis.

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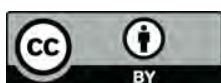
Big data investments in knowledge and non-knowledge intensive firms: what the market tells us

Tingting Zhang, William Yu Chung Wang and David J. Pauleen

Abstract

Purpose – This paper aims to investigate the value of big data investments by examining the market reaction to company announcements of big data investments and tests the effect for firms that are either knowledge intensive or not.

Design/methodology/approach – This study is based on an event study using data from two stock markets in China.

Findings – The stock market sees an overall index increase in stock prices when announcements of big data investments are revealed by grouping all the listed firms included in the sample. Increased stock prices are also the case for non-knowledge intensive firms. However, the stock market does not seem to react to big data investment announcements by testing the knowledge intensive firms along.

Research limitations/implications – This study contributes to the literature on assessing the economic value of big data investments from the perspective of big data information value chain by taking an unexpected change in stock price as the measure of the financial performance of the investment and by comparing market reactions between knowledge intensive firms and non-knowledge intensive firms. Findings of this study can be used to refine practitioners' understanding of the economic value of big data investments to different firms and provide guidance to their future investments in knowledge management to maximize the benefits along the big data information value chain. However, findings of study should be interpreted carefully when applying them to companies that are not publicly traded on the stock market or listed on other financial markets.

Originality/value – Based on the concept of big data information value chain, this study advances research on the economic value of big data investments. Taking the perspective of stock market investors, this study investigates how the stock market reacts to big data investments by comparing the reactions to knowledge-intensive firms and non-knowledge-intensive firms. The results may be particularly interesting to those publicly traded companies that have not previously invested in knowledge management systems. The findings imply that stock investors tend to believe that big data investment could possibly increase the future returns for non-knowledge-intensive firms.

Keywords Knowledge-intensive firm, Event study, Market value, Big data investment

Paper type Research paper

Introduction

The big data phenomenon is widespread and presents great investment potential. It is predicted that global organizations will spend roughly US$48.6bn on big data analytics and relevant services by 2019 (International Data Corporation, 2015). Meanwhile, interest grows in understanding the potential economic impact of investment in "big data" (Tambe, 2014). For instance, a McKinsey report estimates that using big data in the area of healthcare, energy, education, transportation and consumer finance could have a potential annual value of US$3tn (Manyika *et al.*, 2011). Columbus (2016) also reports that increased efficiency, improved decision-making and improved customer experience and engagement are the top three

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benefits of enterprise-wide big data implementation, as they could lead to positive economic returns.

Nonetheless, there are also different signals regarding the actual return value of big data investments. In a McAfee et al. (2012) study, big data investments do not bring significant value to the industry, especially in the European market. Coleman et al. (2016) also shares similar observation that firms in UK and Germany are unsure whether they are going to gain benefits from big data investments.

Moreover, controversial or inconsistent results are found in the literature. For example, both Min and Bae (2015) and Huang et al. (2016) investigated the value of big data investments using the same financial measures (i.e. changes in stock prices). While the former found positive impact brought by big data investment, the latter concluded there was no impact. Consequently, despite the trend of big data adoption, companies may choose to retain the status quo until the benefits are explicitly observed in more cases. There is a need to see more evidence of the actual economic value that big data might bring to a company.

In fact, the surge of big data brings knowledge management to a new era, as big data can provide value in extracting and managing knowledge (Côrte-Real et al., 2017). Therefore, it is important to know whether big data investment is perceived to have potential economic value for firms where knowledge is viewed as a crucial organizational asset (Erickson and Rothberg, 2014). These types of firms are classified in the literature as knowledge-intensive firms, "whose primary value-added activities consist of the accumulation, creation or dissemination of knowledge for the purpose of developing customized products and services" (Millar et al., 2016, p. 844). Recently, a few studies which investigate the impact of big data investments have looked into the characteristics of firms such as firm size and whether the firm is an IT firm (Min and Bae, 2015; Huang et al., 2016). However, there is a shortage of research focusing on whether there would be any difference in the value of big data investments between knowledge-intensive firms and other firms.

Adopting an event study approach, this study examines whether and in what way stock market investors recognize the value of big data investments. Specifically, this study investigates how firm stock prices react to big data investment announcements as direct evidence as to whether such an investment has perceived value for the firm. Such a reaction is further assessed to examine whether the reaction differs for knowledge intensive firms and non-knowledge-intensive firms. This study contributes to the literature on assessing the economic value of big data investments from the perspective of big data information value chain and from the viewpoint of stock market investors. Findings of this study can be useful for decision makers in deciding on big data investments depending on their firm's knowledge-intensive nature.

The rest of the paper is structured as follows. In the next section, big data and its value are discussed. Then the use of signaling theory and efficient market hypothesis as theoretical foundations for the study are justified and two research hypotheses are proposed. This is followed by the research methodology, data collection and data analysis, as well as presentation and discussion of the results. Finally, implications for researchers and practitioners, limitations and future research directions are explained.

Big data and its value

Big data represent great potential for businesses to gain competitive advantage. Big data make it possible to uncover hidden trends and provide insights into future business contexts so that organizations are able to not only deliver the best products or services but also anticipate the behavior of their customers, employees, vendors and partners (Baboo et al., 2013; Arora and Rahman, 2016). Consequently, organizations can take actions in advance to exceed the expectations of those they do business with (Baboo et al., 2013; World Economic Forum, 2012).

Big data information value chain

The extant literature presents a number of ways to understand the value of big data. The term big data is originally understood via the three "Vs", namely, volume, velocity and variety, where volume refers to the magnitude of data generated, velocity refers to the speed of data creation and collection and variety refers to the data sources in a data set (Gandomi and Haider, 2015). Another view of big date defines it as technologies that enable the collection, storage, management, processing and analysis of data that is too large for conventional tools (Tambe, 2014; Portela *et al.*, 2016). Others argue that, skills, expertise and management capabilities are necessary for defining and understanding the big data phenomenon and using technology and analyzing data in an effective way (Shim *et al.*, 2015; Coleman *et al.*, 2016). Although each of the aforementioned ways of defining big data offers a unique perspective to understand the value of big data, none of them captures the value of big data in a comprehensive manner.

It is argued that the big data information value chain provides a unique means to combine the aforementioned three perspectives for understanding the value of big data (Wamba *et al.*, 2015; Abbasi *et al.*, 2016). The information value chain:

> [. . .] is the cyclical set of activities necessary to convert data into information and, subsequently, to transform information into knowledge, which individuals use to make decisions and take action, which then result in outcomes such as business value and additional data (Abbasi *et al.*, 2016, p. 3).

According to Abbasi *et al.* (2016), essential components for each stage of the information value chain (i.e. people, processes and technology) can be used to interpret the role of big data along the value chain. The volume, velocity and variety of big data necessitate changes in how an organization stores and manages data. Traditionally, data are primarily stored in relational databases, whereas big data featured with larger volume, velocity in real-time applications and variety of unstructured data requires innovative data management approaches (Abbasi *et al.*, 2016). In addition, innovative technologies are needed in handling big data (Bhat and Quadri, 2015). For example, new data management systems, such as Hadoop and Spark, have been developed to store and manage big data. Moreover, the arrival of the big data age has generated an urgent need for data scientist and big data analysts (Tambe, 2014; Bughin, 2016).

Indeed, big data have imposed a disruptive impact on the traditional information value chain. In the context of big data, capitalizing data from internal and external sources could turn out to be valuable for accumulating business knowledge, and eventually for making organizational decisions (LaValle *et al.*, 2011; Kwon *et al.*, 2014). This is especially the case for data-intensive industries in which data are key strategic resource for production, such as in financial and IT-related services (Tambe, 2014). For instance, in the financial industry, organizations increasingly make decisions based on reliable insights supported by factual big data (Seth and Chaudhary, 2015). Likewise, appropriate knowledge management systems that communicate insights derived from big data within an organization are found to maximize the value of big data investments (Tormay, 2015). It is also argued that skills, expertise and management capabilities are necessary for understanding the big data phenomenon, using related technology and analyzing data effectively (Shim *et al.*, 2015; Coleman *et al.*, 2016). For example, better productivity performance is found when a company has employees with big data management and analytics skills (e.g. Hadoop skills) (Tambe, 2014).

Big data's impact on the information value chain is especially linked with the role of knowledge, which is at the core of the big data information value chain (Abbasi *et al.*, 2016). In the big data era, knowledge evolves quickly due to the availability of huge amounts of stored and real-time data, as well as the significant reduction of cost for data analytics. As a result, it is possible to openly share and fuse knowledge insights, leadings to the

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appearance of new knowledge (Xu et al., 2016). When more knowledge is developed, managed and exploited, more value is created because knowledge is an important resource that helps firms to achieve a corporate goal and to sustain competitiveness (Cavaliere et al., 2015). In other words, big data are clearly related to knowledge management. Not only does big data provide a tremendous resource for knowledge creation (Côrte-Real et al., 2017) but also knowledge utilization and knowledge transfer are necessary for the effective communication of insights from big data within an organization to maximize the value of big data investments (Tormay, 2015).

Measuring the value of big data

Given the multifaceted means of understanding big data, assessing the value of big data investments requires a comprehensive approach (Schryen, 2013). This is because when organizations view their big data as a type of business asset, assessing its value can be conducted from a traditional accounting perspective (Abbasi et al., 2016). Big data, however, can be viewed as an innovative information system, such as big data storage capacity and grid technologies (Garlasu et al., 2013) and cloud computing (Purcell, 2014). In this sense, the value of big data investments tends to be intangible and emerges over the long term, which can hardly be reflected on the balance sheet (Andoh-Baidoo et al., 2012). Investments in big data can also involve acquiring big data experts (e.g. data scientists, data analytics staff) and other strategic management support (e.g. knowledge management strategies). Such investments are essential for maximizing the value of big data (Tambe, 2014; Tormay, 2015) but can be hardly assessed separately.

Prior studies in the information systems field have proposed a number of possible measures to assess the economic value of information system investments. Some example measures include accounting based measure such as return on investment, return on assets and return on equity (Schryen, 2013), Tobin's Q (Bharadwaj et al., 1999; Bardhan et al., 2013) and stock performance (Im et al., 2001; Andoh-Baidoo et al., 2012; Roztocki and Weistroffer, 2015). Among these measures, stock performance is likely to be appropriate for this study for the following three reasons.

First, the value of big data may be intangible. Hence, it is difficult to use common accounting measures to cover the hidden value of big data investments, such as cost reduction and improvement in products, services and decision-making (Huang et al., 2016). Stock performance can reflect the overall trust of market investors in the ability of the firm to derive benefits from information system investments (Im et al., 2001; Andoh-Baidoo et al., 2012; Son et al., 2014; Roztocki and Weistroffer, 2015).

Second, the value of big data may emerge in the long run. Accounting measures usually report on what has happened, not what will happen (Im et al., 2001). Stock performance can serve as a reflection of the perception of the market investors on the present value of a firm's future benefits gained from an investment in both the short term and the long term (Im et al., 2001; Andoh-Baidoo et al., 2012).

Third, the stock performance can be viewed as a firm's ability to attract further capital on the financial markets when necessary (Roztocki and Weistroffer, 2015). It is important to take into account the perspective of the firms' investors, rather than that of the firms' decision makers, when considering a firm's big data investment for the development of a firm (Min and Bae, 2015).

For these reasons, this study adopts a stock performance measure to assess the economic value of big data investments. Specifically, the change in a firm's stock prices is used to evaluate the reaction of the market investors to its big data investment announcements.

How can an event influence the stock market?

The market reactions to a firm's big data investment announcements can be further explained by signaling theory (Spence, 1973) and the efficient market hypothesis (Fama et al., 1993). Signaling theory holds that in the absence of complete and accurate information, decision makers will interpret observable factors or a signal revealed by a sender and adjust their purchasing behavior accordingly (Spence, 1973). Efficient market hypothesis implies that the revelation of information about an event can evoke an immediate stock price fluctuation (Fama et al., 1993). Relating the influence of the signal sent by an event to a reaction of the stock market allows one to determine whether the event provides valuable information to stock market participants (Eastman et al., 2010).

The announcement of a big data investment may send signals about information on the future profit of a firm (Filbeck et al., 2009). For instance, investments in big data can help a firm to gain a better understanding of its internal and external business environment and to generate insights into business opportunities (Sharma et al., 2014). It can also potentially reduce costs, improve products, service and decision-making (Huang et al., 2016). The emergence of big data provides additional source for new knowledge, valuable insights and innovation, which is essential for a firm to gain competitive advantages. With a more holistic picture of the business environment, decision makers can make more informed decisions to improve firm performance. As reported by McAfee et al. (2012), data-driven firms perform better financially and operationally. Tambe (2014) also finds firms having invested in Hadoop to be associated with 3 per cent faster productivity growth.

When the big data investment signal is observed and understood by stock market participants, the cost and potential earning of the big data investment are justified (Filbeck et al., 2009). Consequently, the investment signal will influence actions of market participants, which will be realized instantly on the stock market (Hannon and Milkovich, 1996). Thus, favorable big data investments may bring an unexpected increase in an organization's stock price (Hannon and Milkovich, 1996). Hence, based on big data investment announcements, investors would perceive that the investment would result in positive outcomes. This leads to the following hypothesis:

H1. The stock market reacts positively to big data investment announcements.

In an era of big data, the essential aspect of the big data value chain is to derive knowledge from big data (Abbasi et al., 2016). It is, therefore, crucial for a firm to take advantage of big data for the acquisition, storage, organization, access and sharing of knowledge (Millar et al., 2016). As firms may have different ranges of dependence on knowledge assets, the value of their big data investments will vary. For knowledge-intensive firms who rely heavily on knowledge for providing customized services and products (Millar et al., 2016), the strategic importance of big data investments seems especially profound. This is because knowledge is more important than other business inputs for a knowledge-intensive firm (Cavaliere et al., 2015). The application of superior knowledge is the main source of competitive advantages for this type of firm (Kärreman, 2010). Hence, investing in big data can have a profound impact on a set of activities associated with the transformation of data into information, and then into knowledge in knowledge-intensive firms (Abbasi et al., 2016). Moreover, big data implementation could enhance knowledge acquisition and broaden the existing body of knowledge so as to derive more insightful knowledge for decision-making (Kabir and Carayannis, 2013; Abbasi et al., 2016). Therefore, when knowledge-intensive firms announce their big data investments, the future return of the investments would be expected by stock market participants to be positive.

Non-knowledge intensive firms, on the other hand, are likely to depend heavily on other types of resources such as labor and capital, rather than knowledge (Kärreman, 2010). In this case, these firms may not have a mature system to derive knowledge from raw data or to disseminate the knowledge derived throughout the firm. As a result, it could be difficult

for non-knowledge intensive firms to gain appropriate insight from big data and eventually to reap even limited economic benefits from big data investments (Tormay, 2015). Because of this, stock market participants would probably show little interest in big data investments made by non-knowledge-intensive firms. Hence, the following hypothesis is proposed:

> *H2.* The stock market reacts more favorably toward big data investment announcements made by knowledge-intensive firms than those made by non-knowledge-intensive firms.

Event study methodology

Event study methodology is considered appropriate for this study because it is a powerful means to examine how stock market participants assess the informativeness of an event (Konchitchki and O'Leary, 2011). The event study methodology was developed based on the efficient market hypothesis (Fama *et al.*, 1993) to assess the effect of a specific event on the stock price of a firm (Andoh-Baidoo *et al.*, 2012). Using this method, the current market value of a firm reflects investors' perception of the present value of all future benefits to the firm in both the long and short terms. Therefore, the effect of an event on the stock price of a firm can be determined by the difference between the actual and predicted returns, which is often termed "abnormal return" (Konchitchki and O'Leary, 2011, p. 102). Since Dos Santos *et al.*'s (1993) initial use of the event study methodology, it has become well established and accepted in the field of Information Systems (Meng and Lee, 2007; Andoh-Baidoo *et al.*, 2012; Roztocki and Weistroffer, 2015). Table I provides a brief summary of research related to the big data value chain using event study methodology. Consistent with other studies that have examined the market value of Information Systems investments, this study followed standard event study methodology. Events of interest, event windows and target firms were first identified, followed by the measurement of abnormal returns for across time and firms.

Determining the event window

This study used a three-day event window consisting of the day of the announcement, the preceding trading day and the trading day following the announcement day. It is believed that a three-day event window is likely to lead to reliable results. This is because, when the event window is increased beyond three days, the power of the estimation model decreases (Lin *et al.*, 2007; Jacobs *et al.*, 2010). Moreover, with a long-term event window, there might be confounding events affecting a firm's market value within the same period. Choosing a shorter event window can help to diminish the contamination of stock price data during the event window by confounding events such as dividend, earning, merge/acquisition and changes in top management (Lin *et al.*, 2007; Jacobs *et al.*, 2010).

In this study, a 250-day estimation period was used, starting 252 trading days and ending two trading days before the date of the announcement. In total, 250 days are roughly about the number of trading days in a calendar year. Using such a relatively long estimation period can lessen the influence of possible seasonal stock price movements (Corrado, 2010). In addition, a longer estimation period ensures adequate observations for estimating the parameters (Dobija *et al.*, 2012).

Selecting big data investment announcements

A procedure for sample selection used by Dos Santos *et al.* (1993) was followed in this study. Wind financial terminal database was used to identify announcements of big data investments until the end of July 2016. Search terms included "big data" together with action verbs (such as plan to purchase, install, develop, invest, implement and analyze) or corresponding nouns. An initial search yielded 501 available announcements. These were analyzed and evaluated for inclusion in further analysis based on the following sampling criteria:

Table I Big data related event studies and some characteristics

Researchers	Topic	Period of announcements	Factors	Sample size	CAR window	Estimation window	Major findings
Choi and Jong (2010)	Knowledge management strategy-related announcements	January 1, 1998- December 31, 2003	Types of knowledge management strategy Industry type	79	(−2, +2)	(−122, −3)	Positive reaction to knowledge management strategy announcements Industry type determines the magnitude of market reaction
Huang et al. (2016)	Big data implementation	January 1, 2010- March 15, 2015	Technology type The objective of big data implementation IT firms vs non-IT firms	40	(−1, +1) (−3, +3) (−5, +5) (−10, +10)	(−180, −11)	No reaction to big data implementation announcements overall and regardless of the technology type, the objective, or IT firms or not
Huntgeburth et al. (2013)	Cloud computing adoption	January 2007 - June 2012	Innovativeness Firm size Industry cluster Industry sector Strategic Intent Timing	65	(−3, +3)	(−258, −4)	Positive reaction for innovative adoptions Positive reaction for large firms Positive reaction for firms in the services industry cluster Positive reaction for firms in financial, health care and IT sector Positive reaction for adoptions with automate and informate strategic roles Positive reaction for adoptions made in earlier years
Min and Bae (2015)	Big data investment	July 2011-June 2014	Firm size	84	(−5, +5)	(−260, −10)	Positive reaction on the event day and the day after No evidence of firm size affecting market reaction
Sabherwal and Sabherwal (2005)	Knowledge management and business strategies	January 1, 1989- December 31, 2002	Related experience Time Return on assets Firm size	89	(−2, +2) (−3, +3)	(−300, −46)	Positive reaction to knowledge management announcements with the (−3, +3) window greater than the (−2, +2) window Positive reaction when there is an alignment between the knowledge management process and firm efficiency *(continued)*

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Table I							
Researchers	Topic	Period of announcements	Factors	Sample size	CAR window	Estimation window	Major findings
Sabherwal and Sabherwal (2007)	Knowledge management and business strategies	1995 to 2001	Firm size Alignment Time	103	(−2, +2)	(−300, −46)	Positive reaction to knowledge management announcements The magnitude of positive reaction is affected by firm size over a 2-day CAR window Greater positive reaction for firms with a higher level of alignment between the knowledge management effort and the business strategy over a 3-day CAR window
Son et al. (2011)	Cloud computing adoption	2005 - 2010	Strategic intention Firm size Industry SaaS vs Non SaaS announcements	183	(−1, +1)	(−121, −2)	Greater positive reaction for adoption with internal focus than for external focus Positive reaction for large and SME firms Positive reaction for non-SaaS cloud computing adoption Positive reaction for firms in the nonmanufacturing sector
Son et al. (2014)	Cloud computing initiatives	January 1, 2006-December 31, 2011	Firm size Prior experience Cloud service type Cloud implementation type Cloud benefit Vendor reputation	212	(−1, +1)	(−256, −2)	Positive reaction to the cloud computing initiatives Positive reaction for smaller firms Positive reaction for adoption with operational benefits The magnitude of positive reaction is larger for initiatives integrated within a firm's existing systems

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- Only announcements by firms that were traded on either the Shanghai Stock Exchange or Shenzhen Stock Exchange were included.

- Only announcements by firms whose stock price information was continuously listed over the three-day event period and the 250-day estimation period were included.

- If there were duplicate announcements describing the same big data investment, only the first announcement was included. If there were more than one announcement with the same date, only the one which provided the most details about the investment was included.

- Announcements which had confounding announcements during the event three-day event window were excluded, such as announcements about dividend, earning, merge/acquisition and changes in top management.

In total, 319 announcements were screened out during the sample selection period. Eighty-two announcements were excluded because the stock price information for corresponding firms was not complete over the 253 days included in this study. Sixty-seven duplicate announcements about the same big data investments and two different announcements on the same day were excluded. Another 168 announcements were excluded because of the existence of confounding announcements over the three-day event window period, including 72 for dividend or profit disclosures, 78 on merger, acquisition, investment and 18 on changes in top management and administrative policies. In the end, these sampling criteria resulted in a total of 182 big data investments announcements from 2012 to July 2016.

Another four announcements were further excluded during the process of calculating normal returns (the procedure is described in the *Calculating abnormal returns* sub-section). For these four announcements, the beta estimates derived from equation (3) (i.e. $\hat{\beta}$) were not statistically significant. Such results meant that the normal return on each particular day during the three-day window for the four announcements cannot be calculated by using equation (4) for subsequent analysis (Min and Bae, 2015).

Overall, 178 announcements were included for further data analysis. The first announcements about big data investments were made in 2012. This is consistent with the big data phenomenon in China. Table II demonstrates the annual number of announcements about big data investment.

Data description

The sample of this study consisted of 178 announcements made by126 firms listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange. The search for big data investment announcements was conducted using the Wind Financial Terminal Database, as was the retrieval of the daily stock returns of the individual firms. As a proxy for stock market returns, the daily return of the Shanghai Stock Comprehensive Index and the Shenzhen Stock Index was used.

The industry information of each firm was also obtained from the Wind Financial Terminal Database. The Wind Industry Classification Standard was adopted for categorizing the

Table II	Annual numbers of announcements about investment in big data
Year	No. of observations
2012	2
2013	21
2014	41
2015	79
2016, till end of July	35
Total	178

selected firms. This standard is based on the Global Industry Classification Standard with minor justification to the characteristics of listed firms in China (Zhao, 2012). The Global Industry Classification Standard has been widely used in stock market research and is considered to be a better choice for financial analysts and investors than other industry classifications (Bhojraj *et al.*, 2003; Hrazdil *et al.*, 2013). Therefore, it is reasonable to believe that using the Wind Industry Classification Standard fits well with the purpose of this study, which is to understand investors' behavior in the stock market. In this sense, it can be argued that the findings from this study are likely to be comparable with findings from studies conducted in stock markets in other countries.

For the purposes of testing *H2*, the industries were further classified into knowledge-intensive firms and non-knowledge intensive firms by following the classification standard developed by the Organization for Economic Co-operation and Development. The reliability of such a classification approach has been testified in prior studies (Bonaccorsi *et al.*, 2014; Morariu, 2014). Table III provides an overview of sample description. In the sample, there were 84 announcements made by knowledge-intensive firms and 94 announcements by non-knowledge-intensive firms.

Calculating abnormal returns

To measure the aforementioned change of a firm's financial performance triggered by the events of big data investment announcements, the normal rates of return were estimated by following the approach of Brown and Warner (1985). The stock return of firm *i* on day *t* (i.e. R_{it}) and the stock return of market portfolio on day *t* (i.e. R_{mt}) were first calculated using equations (1) and (2), respectively, where P_{it} is the stock price of firm *i* on day *t* and P_{mt} is the stock market price index on day *t*.

$$R_{it} = \frac{P_{it}}{P_{it-1}} - 1 \qquad (1)$$

$$R_{mt} = \frac{P_{mt}}{P_{mt-1}} - 1 \qquad (2)$$

Then, according to the efficient market hypothesis (Fama *et al.*, 1993), the return of a specific stock can be represented as a function of the market portfolio, as represented by equation (3), where R_{it} represents return of stock *i* on day *t*; R_{mt} is the return of the market portfolio on day *t*; α_i, β_i are the intercept and slope parameters, respectively, for firm *i*; and ε_{it} is the disturbance term for stock *i* on day *t*. These parameters were estimated using stock price data observations over a 250 day-period ending two trading days before the events, i.e. day (-2). Then, regressions were run for R_{it} on R_{mt} as presented in equation (3) to derive $\hat{\alpha}$, and $\hat{\beta}$ in equation (4). Finally, the normal rate of return of firm *i* on day *t* (i.e. $\hat{R}_{it}$) was calculated using equation (4).

Table III Industries of big data investment firms

Industries	No. of observations	Type of firm
Energy	1	non-KIF
Materials	10	non-KIF
Industrials	17	non-KIF
Consumer discretionary	33	non-KIF
Consumer staples	3	non-KIF
Utilities	30	non-KIF
Healthcare	5	KIF
Financial	9	KIF
Information technology	68	KIF
Telecommunication Services	2	KIF
Total	178	

Notes: KIF: knowledge intensive firms; non-KIF: non-knowledge intensive firms

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it} \tag{3}$$

$$\widehat{R_{it}} = \widehat{\alpha_i} + \widehat{\beta_i} R_{mt} \tag{4}$$

Abnormal rate of return for firm i on day t within the three-day event window was derived using equation (5). Then, the cumulative abnormal return (CAR) for stock i over the event window was computed as Equation (6), while for a sample of N stocks the average CAR over the event window is represented by equation (7), where N is the number of observations included in the sample or subsample. Furthermore, the CARs were further tested for statistical significance using equation (8).

$$AR_{it} = R_{it} - \widehat{R_{it}} \tag{5}$$

$$CAR_i = \sum\nolimits_{T1}^{T2} AR_{it} \tag{6}$$

$$CAR = \frac{1}{N} \sum\nolimits_{T1}^{T2} CAR_{i(T1,T2)} \tag{7}$$

$$z = \frac{average\ of\ CARi}{standard\ deviation/\sqrt{N}} \tag{8}$$

Findings and discussions

Table IV shows the CARs of all the firms obtained over a three-day event window. The generalized sign test is a comparison of the proportion of events with positive abnormal returns and that negative abnormal returns (Cowan, 1992). As shown in Table IV, there is a dramatic increase on day 0 and day (0,1) (i.e. from the announcement day to the day after). For day 0, the ratio of number of events with positive CARs to those with negative CARs is greater than 1 (107:71) with a generalized sign Z value indicating that the CAR for day 0 is positive and significant at the 1 per cent level. For the (0,1) event window, the ratio of number of events with positive CARs to those with negative CARs is greater than 1 (100:78) with a corresponding generalized sign Z value implying that the CAR for day (0,1) is positive and significant at the 1 per cent level. Therefore, $H1$ is supported.

This finding aligns with Min and Bae's (2015) that big data investment announcements have positive impact on the stock prices of sample firms. Such a finding suggests that big data investments can enhance investors' beliefs that firm value will increase in the future.

The results of the CARs for knowledge intensive firms and non-knowledge intensive firms are presented in Table V. For knowledge intensive firms, none of the CARs on any day or

Table IV Cumulative abnormal return for all the firms

Event day(s)	Cumulative average abnormal return (%)	Z	Positive:negative	Generalized sign Z
−1	−0.70	−1.397	78:100***	8.524
0	1.11***	3.428	107:71***	14.022
1	−0.21	−0.779	82:96***	14.751
(−1,0)	0.41	0.721	88:90***	11.297
(0,1)	0.90**	2.084	100:78***	14.752
(−1,+1)	0.20	0.319	97:81***	12.017

Notes: ***Significant at the 1% level; **significant at the level of 5%

Table V Cumulative abnormal returns for knowledge-intensive firms and non-knowledge-intensive firms

Type of firm	No. of observations	−1 (%)	Z	0 (%)	Z	1 (%)	Z	(−1,0) (%)	Z	(0,1) (%)	Z	(−1,1) (%)	Z
KIF	84	−0.70	−0.928	0.90	1.929	−0.20	−0.395	0.20	0.208	0.70	1.239	−0.30	−0.295
non-KIF	94	0.50	1.421	0.40	1.081	0.20	0.779	1.50**	2.529	0.90*	1.925	1.80***	2.787

Notes: ***Significant at the 1% level; **significant at the level of 5%; *significant at the level of 10%

any event window over the three-day event window period is found statistically significant. Statistically significant CARs are observed for non-knowledge-intensive firms during event windows $(-1,0)$, $(0,1)$ and $(-1,1)$ at the significant level of 5, 10 and 1 per cent, respectively. This means that *H2* is not supported.

This is an interesting finding as it suggests that stock investors evaluate the future benefits of big data investments depending on whether the firm is knowledge intensive or not. Also, stock market investors would be more optimistic toward big data investments made by non-knowledge-intensive firms. Possible explanations for such a finding are as follows.

Big data investments publicly announced by non-knowledge-intensive firms could be seen as an initial step of exploratory investing in a large project intending to take advantage of data (Portela *et al.*, 2016). The announcement sends a message to investors that the organization is in the process of implementing an innovation. Prior studies on innovative information systems adoption have proved that this type of announcement invokes an increase in a firm's stock price (Konchitchki and O'Leary, 2011). Hence, announcements about big data investments probably signal increases in future benefits of the big data investment and investors would react positively accordingly.

On the contrary, for knowledge-intensive firms, big data are usually used as an extension of what already exists (Portela *et al.*, 2016). As some researchers have pointed out, a knowledge-intensive firm must devise appropriate knowledge management mechanisms such as strategies, policy, infrastructure and training that enable the company to maximize the value of their big data investments (Tormay, 2015). Without further investments to support the big data implementation, investors may perceive that the current big data implementation adds limited value to firms that may already have infrastructure or resources to conduct big data analytics.

Moreover, when a big data investment is viewed as an extension of the existing resources and systems, knowledge-intensive firms may overlook the real business need of such investments (Lavastorm Analytics, 2014). When investors are unable to see a clear objective of a big data investment, they probably perceive that the investment would not lead to future benefits or may even bring negative effect on future profit as the big data investment can be a risk investment (Portela *et al.*, 2016). Huang *et al.*'s (2016) study provides some evidence for this suspicion. They (Huang *et al.*, 2016) found that announcements made by firms whose news coverage mentioning the objective of big data investments have a positive impact on the firms' CARs over a 21-day event window. Whereas, announcements not mentioning the objective of big data investments have negative impact on firms' CARs over an 11-day and a 21-day event windows (Huang *et al.*, 2016).

Conclusions

Based on signaling theory and the efficient market hypothesis, this study investigated how the stock market recognizes the value of big data investments by checking the relationships between investment announcements and the variation of stock prices. The results show that big data investment announcements bring increases in a firm's stock price in general and in non-knowledge-intensive firms in particular. These findings have implications for research and practice.

This study makes an effort to answer the calls for assessing the economic value that big data investments can bring to a firm (Abbasi *et al.*, 2016; Côrte-Real *et al.*, 2017). By viewing market reactions, this study suggests that market reaction can serve as a comprehensive measure for understanding the economic value of big data investment. Building upon the big data information value chain, this study also points out a relationship between big data and knowledge management.

In addition, the current paper addresses the questions that how return on investment in big data can be perceived and when a firm should invest in big data using an event study approach. Although few prior studies have specifically focused on the impact of big data investment announcements on firms' stock prices, they have generated controversial or inconsistent results. For example, Min and Bae (2015) find positive impact of big data investment news on firm stock prices based on data from 84 firms. However, Huang et al. (2016) find no impact using a sample consisting of 40 big data investment announcements. This paper contributes another empirical study to the literature on examining the economic value of big data investments from the perspective of stock market investors using a larger sample size of 178 from a major stock market compared to the extant literature.

Moreover, this study takes an innovative perspective to understand the association between big data investments and the market's perception of the investment under different firm conditions. Prior studies have compared the market reactions to big data investment news between firms of different sizes (Min and Bae, 2015) and between IT firms and non-IT firms (Huang et al., 2016). This study looks into the differences in the market reaction toward big data investment announcements made by knowledge-intensive firms and non-knowledge-intensive firms. Given that data are the fundamental element from which to derive knowledge (Abbasi et al., 2016), it is important to understand investors' attitudes toward big data investments in both knowledge-intensive firms and in non-knowledge-intensive firms.

For practitioners (including executives and managers), this study provides support to justify big data investments. The results that stock markets react positively to big data investments announcements indicate that investors tend to believe that firms will gain significant earnings from big data investments in the future based on their interpretation of the investment announcements. Therefore, this study can be used to refine these practitioners' understanding and thinking about their investors' expectations about the future earnings from big data investments. In addition, results of this study suggest that decision makers can use the possible perceived value of big data investments by the stock market to prepare or adjust the implementation of their big data investments. This would optimize their investment decisions.

In particular, this study suggests that practitioners from firms with different levels of knowledge intensiveness need to consider big data investments with caution. Practitioners of non-knowledge-intensive firms may particularly consider making or increasing investments in big data as the investments would enhance investors' trust in the future performance of the firm. However, the expansion of big data implementation imposes challenges for knowledge-intensive firms. These firms might need to focus mainly on how to align their knowledge management strategies with big data implementation (Kabir and Carayannis, 2013). Alternatively, knowledge-intensive firms may need to upgrade their knowledge management systems to make full use of big data for strategic and competitive advantage (Kabir and Carayannis, 2013).

Some limitations and future research are noted here. Firms that are not listed on the stock market may need to interpret the results of this study with caution because the event study methodology only allows for the investigation of firms with stock prices available. Hence, further studies can try different approaches to examine the economic value of big data investments for firms that are not publicly traded on the stock market. In addition, although results of this study indicate that the stock market is more favorable toward big data investments made by non-knowledge-intensive firms, further research is needed to confirm the reasons leading to such results. Moreover, as a common challenge for event studies, there might be additional factors affecting stock performance, which were not considered in this study; for example, whether big data investments are innovative or follow-up investments may affect a firm's market performance (Dos Santos et al., 1993). Similarly, the amount of big data investment expenditure might result in variation in stock price

fluctuation. Therefore, future studies could consider investment-related features to capture the market performance of big data investment in more detail.

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China's Water-Saving Irrigation Management System: Policy, Implementation, and Challenge

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Abstract: In response to the increased competition for water, the Chinese government has determined to promote water-saving irrigation (WSI) followed by a range of institutional arrangements and policy goals. Three management mechanisms are analyzed in this study in terms of effectiveness, including the top-down regulation mechanism using direct control or economic instruments, the design-bid funding mechanism mobilizing local governments by competitive grants program, and the bottom-up participation mechanism transferring more irrigation management responsibilities to end-users. Although the WSI management has achieved notable improvements by the combination of different mechanisms, conflicts among different policy goals, uneven distribution of financial resources, and insufficient participation from water users caused the difficulty in aligning stakeholders' incentives. Approaches are needed to enable sustainable management by coordinating incentives from different stakeholders in the management, as well as incorporating end water users to assist decision-making.

Keywords: management reform; top-down regulation; design-bid funding; bottom-up participation; Shiyang River Basin

1. Introduction

China encompasses almost 20% of the world's population with only 6% of the world's fresh water [1], leaving it with much less water available per capita than most other countries. Over the past few decades, expanding agricultural production, increasing industrial output and growing population with more water-intensive lifestyles have all exacerbated the scarcity of China's available water resources [2]. Faced with growing competition from urban and industrial sectors, the agricultural sector is likely to experience serious water scarcity problems in the near future. These problems are aggravated by the low economic output per cubic meter of water. Furthermore, socioeconomic development will require more food production [3], leading to the further demand for water in agriculture. In the meantime, the agricultural sector still consumes the largest proportion of the county's water (62.4% in 2016) [1], but with a low level of water use efficiency. Specifically, the ratio of the volume of water used productively by crops to the total quantity of water supplied was 0.55 in 2016, far behind the developed world of 0.7–0.8 [1,3]. Thus, in response to the increased competition for water, there is great potential for water-saving irrigation (WSI) to achieve sustainable water use while maintaining agriculture development in China.

To address the above concerns, various WSI technologies have been developed to save water use in agriculture from the supply of irrigation water to its final use on crops. Wang et al. [4] made one of the earliest attempts to summarize the various technologies, and divided them into two categories: engineering measures, such as canal lining, drip irrigation, and intermittent irrigation; and agronomic practices, such as water-matched production, biological water-saving technology,

and soil moisture conservation. Wang et al. [5], on the other hand, divided WSI technologies into three categories: traditional technologies, such as border irrigation and furrow irrigation; household-based technologies, such as using plastic sheeting and surface pipe; and community-based technologies, such as drip irrigation, using underground pipe and canal lining. Other studies have investigated the implementation of these technologies, their adoption, real impacts, and the problems encountered in carrying them out. For instance, Deng et al. [6] discussed various biological mechanisms of the WSI technology in the arid and semiarid areas of China; Chai et al. [7] analyzed the implementation of WSI technologies in China and its social, economic, and environmental impacts. Zou et al. [8], Ingman et al. [9], Tang et al. [10], Feike et al. [11], Khor et al. [12], and Mamitimin et al. [13] investigated the factors influencing the adoption of some of the widely-implemented WSI technologies. Undoubtedly, the practices of WSI technology are of broad interest, with much learned from these, and other, studies.

Nonetheless, the extent of WSI technology use remains low in China [4–7]. To facilitate a more successful adoption of WSI technologies, a set of policies have been pioneered by the Chinese government to foster management change. However, the administrative multi-level and multi-sector structure limits the effectiveness of these policies [5]. Additionally, financial shortfalls from the local governments [14,15] and insufficient participation of farmers [16] also affect the implementation and success of WSI policies [17,18]. As a response, WSI management has been reformed to intensify the connection among macro-level water-saving policies, meso-level policy implementation, and micro-level irrigation water users. For instance, the central government has issued policies to mobilize local governments by providing special funds to fill the fiscal gap for WSI investment [19,20]; Water User Associations (WUAs) have been promoted to take on the irrigation management responsibilities in rural China [21]. In the changing policy environment in China, it is essential to conduct more detailed and empirical assessment of the performance of WSI strategies taken by the government and farmers. Unfortunately, there have been relatively few studies focusing on the status of the WSI management system. There is almost no systematic information on management mechanisms of the WSI, its experience and lessons, although they are urgently needed.

This study aims to enrich the current understanding of the on-going WSI management policies, the mechanisms of how WSI policies have been implemented, and the challenges that the management system is currently facing, thus providing information for further sustainable WSI management. To this end, we have collected data and information on the way that agricultural water has been managed and the effectiveness of different management measures. A case study, carried out in the Shiyang River Basin, has also been analyzed in this paper to illustrate the consequences of the WSI management reform in practice. The research method used in this paper includes an extensive and critical review of academic literature on the technologies, institutions, policies, strategies, and progress involved in WSI. For the case study, we organized site interviews and focus group discussions with a variety of stakeholders from June 2016 to August 2017 to collect information on local water management regulations, government plans, and other relevant information on the studied area.

The remaining sections of this paper are organized as follows: Section 2 provides an overview of China's WSI management policies and its implementation; in Section 3, we give a more detailed discussion of the WSI management by providing empirical evidence for their implementation in the Shiyang River Basin; and Section 4 summarizes the findings and concludes the paper.

2. Overview of Water-Saving Irrigation Management

2.1. Institutional Arrangements

The administrative structure of China's agricultural water management has grown into a vast and complex bureaucracy with overlapping competences and responsibilities [22,23]. China's political administration structure consists of five hierarchical levels: centre, province, prefecture, county, and township [24]. According to China's Water Law [25], the Ministry of Water Resources (MWR)

has the primary responsibility for agricultural water management at the central level. The role of the MWR is to develop and enforce water government laws and regulations, and to supervise water-saving investments by providing technical guidance. In addition to the MWR, other central authorities in China are also involved in the management of the agricultural water management by law [25], including the Ministry of Agriculture which is responsible for developing local water allocation schemes and extending water-saving technology, the Ministry of Environmental Protection which plays a crucial role in water pollution prevention and control, the Ministry of Geology and Mining which provides the information about the groundwater level with respect to groundwater pumping permits, and the State Price Bureau which assists in setting irrigation water price guidelines at the provincial level.

Below the central government, many subnational water management authorities also influence the implementation of the WSI. The Water Resources Bureaus at the provincial level, and the Water Affair Bureaus at the prefectural and county level take most responsibilities for executing WSI policies [26,27]. Those bureaus all link vertically to the MWR to implement the decisions by a higher-level authority. Horizontally, the heads of local bureaus are appointed by local leaders of their own jurisdiction, and thus water management rules and policies were frequently carried out as influenced by local interest [5]. To deal with potential water use conflicts among different jurisdictions, water resources management opted for river basin authority that manage the whole basin's water across administrative boundaries [23,25]. Each of China's seven major river basins, such as the Yellow River Basin, has a National River Basin Conservation Commission, working on behalf of the MWR to manage the basin's water resources. For some of the important basins that lie within the same province, but across different prefectural levels, such as the Shiyang River Basin in Gansu Province, a Provincial River Basin Conservation Bureau has been set up to exert managerial responsibilities empowered by the provincial Water Resources Bureau. The key tasks of the river basin authority are to set an annual quota for water delivery, constructing WSI conveyance structures, and providing more reliable timely irrigation water deliveries of the river basin under their charge [25,26].

Most of the large and mid-sized Irrigation Districts (IDs) have specially set-up bureaus which are responsible for agricultural water conservancy facilities and agricultural water allocation [28]. The ID management bureau is a professional agricultural management organization and their leaders report to local water Resources/Affair Bureaus. Under the ID management bureau, the irrigation stations at township level are directly responsible for allocating agricultural water, maintaining irrigation facilities, and collecting irrigation water fees. Each village has coordinators with executive responsibility given by irrigation stations. Small IDs will be managed directly by a collection of village farmers, with the managers of the small IDs being either village leaders or informally chosen leaders by consensus.

2.2. Water-Saving Irrigation Policies

Agricultural water management has been changed from supply-side management to demand-side management since the revision of China's water law in 2002 [29]. Historically, projects focusing on exploiting more water to meet the increasing water requirements have been given the highest priority. Various surface water and groundwater exploiting projects were built to support the expanding of irrigation areas and the growing of water-intensive crops. However, the cost of exploiting new water resources is increasing especially where the groundwater table has fallen significantly, and massive reliance on irrigation has also produced adverse ecological outcomes [30]. It has become clear that a supply-side approach is insufficient to deal with the growing water demands [30,31]. Gradually, the management objective has shifted to stem the excessive rising demand by the more efficient use of irrigation water.

The 11th Five-Year Plan (2006–2010) [32] set out a series of policy goals for the WSI management. These included (a) shifting from supply-side to demand-side management and quota control; (b) adopting a more unified river basin management system and integrating it with regional development; (c) establishing a preliminary system of water rights trading; (d) developing the WSI

to improve the water use efficiency to achieve a zero growth of agricultural water consumption; and (e) increasing the average agricultural water-use efficiency from 0.45 in 2005 to 0.50 by 2010. The 12th Five-Year Plan (2011–2015) [33] emphasized the following water-saving management goals: (a) implementing the strictest water resources management system with volume control and quota management, and perfecting the water allocation scheme; (b) reforming the water price system; (c) promoting WSI techniques and adding 5×10^7 mu (1 mu = 666.7 m^2) of high-efficiency WSI area; and (d) increasing the average irrigation water-use coefficient to 0.53 by 2015. The current 13th Five Year Plan (2016–2020) [34] also has plans for water resource management, which includes: (a) continuing to implement the strictest water resources management system; (b) limiting the production scale, which should be based on local water resource conditions; (c) increasing the average irrigation water-use efficiency to 0.55 by 2020 and 0.60 by 2030, respectively; and (d) reforming agricultural water price and promoting the practice of the WSI.

2.3. Three Management Mechanisms for Agricultural Water Saving

To implement national WSI policies, the traditional management mechanism is a top-down mechanism, which includes direct control and economic instruments [35,36] with responsibilities assigned over a range of vertically—and horizontally-interlinked government authorities. However, a lack of coordination inherent in China's administrative structure hampered the effectiveness of policy delivery [37,38]. In recent years, the central government has delivered WSI policies with greater reliance on task-specific governance. Instead of using a chain-of-command sense, the central government realizes WSI goals using the application model. Special funds have been designed at the central-level and reached to the basic-level directly [14,17,37], which bypasses the conventional hierarchy. Nonetheless, a lack of alignment and connection between the government and end-users of irrigation water led to the high cost and low efficiency in implementing WSI policies. These concerns have encouraged participatory irrigation management reform by introducing the Water User Associations (WUAs). The WUAs have been considered as a bottom-up organizational form of water governance aiming at enhancing better irrigation performance [16,19,39,40]. Below, we present the three management mechanisms: top-down regulation, design-bid funding, and bottom-up participation.

2.3.1. Top-Down Regulation

The top-down bureaucratic system empowers the central government to have more control over decision-making than lower-level governments. In the case of the WSI, this mechanism includes direct control and economic instruments [36], aiming at allocating water resources and increasing farmers' awareness of their irrigation costs.

The direct control relies on mandatory measures, such as reducing the area of irrigated farmland, restricting the cultivation of high water-consuming crops and introducing a water consumption permit system. The permit system, which was introduced to China's water law in 2002 [25], stipulates that river basin management authorities and local bureaus should set their irrigation quotas among different administrative regions. All water users should obtain their allocated water with permits from the water management authorities and should not exceed the allocated amount. The approved abstraction permit is formulated according to river basin' water allocation plans issued by the upper-level water administrative department or the river basin management authorities [41]. Permits for IDs are the amount of water that can be used for crop production. The implementation of, and emphasis on, the quota management in the agricultural sector began only in recent years and remains in the pilot phase [41,42]. In some of the pilot areas, water use permits have also been assigned to individual farmers and vary annually by water supply and crop type [31]. Farmers deposit money for the allocated amount according to the permit, and the irrigation stops once the allowed volume is acquired [30]. By the establishment of a permit system, individual farmers have de facto rights to agricultural water through their ownership of a permit. In theory, this kind of water right can be traded,

but farmers hardly ever sell their water to others because of the high transaction cost in finding trading partners and the flat trading price determined by the IDs [30,31,42]. Mandatory measures negatively affected farmers' agricultural income, resulting in a low support rate of the policy enforcement [43,44].

Economic measures made based on market signals have also been introduced. The water price reform is the major part of economic instruments in China's WSI policies [5,22]. The first-time water pricing regulation was made in the early 1980s when the state council determined to build a water fee accounting system [22]. Since then, the pricing policy, which prescribed that agricultural water should be treated as market goods to adequately cover the water supply cost, has been reformed. In 2016, a comprehensive agricultural water pricing reform was initiated to gradually increase the water price to guarantee the operation cost of irrigation projects, adjust pricing strategies to encourage saving and punish wasting, and invest in water-saving infrastructure and facilities to lower the cost of the water supply [45]. The water price reform has caused an increase in the price of water to address the nation's water crisis. However, China's farmlands are highly fragmented and small-scale in nature [6,20], and infrastructure for monitoring flows at the individual user level is still unfeasible due to high cost. Thus, water fees are usually collected above the household level. That is, individual households pay a proportion of the total collected water fee based on the size of their irrigated land and regardless of the actual amount of water they have consumed [28]. Further, farmers' water demand is relatively inelastic under the current water pricing system [46], and raising the price will not likely decrease irrigation water use by a significant amount [11,12]. Only a tremendous increase in water price would lead to a significant reduction in farmers' water demand [47,48]. However, such a high increase in the water price occasionally conflicts with other policy goals, such as raising rural incomes and maintaining food security. All these difficulties impede the progress of water price reform.

2.3.2. Design-Bid Funding

In contrast to the central government's strong determination of promoting the WSI, local governments have responded slowly because of the institutional barriers inherent to China's administrative structure. Recently, a significant trend in management reform has been the direct allocation of WSI funds in grant programs [37,49–57]. The grant programs are designed by the central government with specific water-saving outcomes [20,52]. Local governments bid for the WSI program in order to obtain additional benefits other than general operating funds [20]. Thus, we refer to the designing and bidding of grants program as "design-bid funding" mechanism for the WSI management. One of the major factors driving the design-bid mechanism is the fiscal deficits of local governments [17,18,38]. Since China's revenue-sharing reform in 1994, the central government has increased its ability in collecting taxes by the recentralization fiscal control [49] and, thus, decreased the revenue for local government. Further, the complete elimination of agricultural tax in 2006 continued moving fiscal control away from local governments and shifted it to the central government [17]. Consequently, the provision of public services, such as WSI promotion, has increasingly depended on the funds provided by central governments' fiscal transfers [14,15]. The affluent central government also has the capacity and will to invest in the WSI by designing special funds, and asks local governments to apply for the funds by the competition with other local governments [20,56]. This design-bid mechanism in the WSI management is quite different from the top-down regulation, as local governments have the autonomy to decide whether they would like to apply for the funds or not. Meanwhile, this mechanism also provides the central government with an effective controlling power by a task-centred mode of mobilization [50].

The design-bid mechanism also makes a full use of the bureaucracy system while reducing the vertical and horizontal administrative barriers [54]. The central government addresses the nation's growing water shortages by designing competition funds for the investment in village-level irrigation systems. To offset the shrinking revenues, local governments will do the best to win the bid by setting up a team from different departments and integrating the information from these departments [17,37]. Additionally, getting the funds will also rebound to local officials' credit [52–55].

Thus, the design-bid mechanism realizes the water-saving goal through the coordination between the central and local governments. In local government's pursuit of external funds, vertical hierarchical institutions and horizontal departmental arrangements will be broken up and recombined for a short-term [50]. Additionally, the status of the WSI development will be synthesized and submitted to the upper-level government [56]. Consequently, local officers have the incentive to discover the potential water using problems within their jurisdiction during the application process [37,50,56].

The competition for funds from the design-bid mechanism play an increasing role in water conservation engineering and demonstration work [57]. However, the mechanism also faces with striking deficiencies in application and implementation. During the application, the central government will provide guidelines with specific objectives and strict rules on realizing the objectives [52]. Low-level governments have little voice in the formation of guidelines, such as the promotion of drip irrigation among smallholders, and a lack of understanding of the farming practice led to a wasteful use of funds [51]. Moreover, WSI funds were frequently allocated to highly-advanced water-saving technologies, such as automatic irrigation. The advanced technologies are usually favoured by large-scale operation farmers or enterprises because a considerable labour input can be saved together with saving water [53]. Those entities also have the power to lobby authorities and obtain financial support [56]. The government, on the other hand, is eager to create "highlights" in the shortest possible time, requiring that the project pilot units must have strength. This, in turn, means that the priority will be given to those with larger operation scales, and that little attention has been paid to smallholders who will contribute a more significant potential for water savings through water management [22]. Lastly, each of the funds has its specific objectives to the view of higher authorities, but all local affairs involve synthesis [37]. Thus, local governments always combine different funds into one area [57], leading to the uneven distribution of fiscal resources and widening development gap among regions.

2.3.3. Bottom-Up Participation

Both the top-down mechanism and design-bid mechanism are nested in the authority system which excludes water users from the decision-making process. The Water User Associations (WUAs), as a public participatory organization, are considered as an effective entity for democratic decision-making at the lowest level [16]. The potential advantages of WUAs include better facilitating water-related affairs, such as water fees' collection and water delivery, improvement in resolving water use conflict such as opportunistic behaviour prevention, and lower costs of operation and maintenance of the irrigation system [16,40,43,58]. Since the mid-1990s, by introducing the WUAs, the participatory irrigation management reform has become the mainstream in China [43]. In 2005, the central government announced that the WUAs were a way for the effective water management [59] and determined to introduce the WUA over much of the country. However, in its implementation, increasing the number of WUAs or irrigated areas covered by WUA-based management has become the priority objective, and led to a rapid growth of the WUAs numbers [60]. By the end of 2014, 834,000 WUAs had been established and commanded 284 million mu farmlands, which comprised 29.2% of the country's effectively irrigated area [61]. With the establishment of WUAs, irrigation management responsibilities have been transferred from the government agencies to local water users to manage the agricultural water more effectively in a decentralization way. However, the performance of the WUAs varies considerably in water-saving [60,62–64].

The bottom-up WUAs formalized by the World Bank [40], and replicated in China with little attention to local context, resulted in a low success rate [39,40]. In China, the village is the lowest-level administration unit, and the leaders of village include both village committee head elected by village members and party secretary selected from above by the party organization. Since WUA has the identical administrative boundaries with the village rather than the established based on hydrological boundaries, the WUA board is usually comprised of the village leadership [58,64]. According to data from a large-scale survey during 2012 and 2016, it is estimated that 61% of the

investigated WUA board was promoted by village leaders and that only 14% were elected through the democratic voting process [65]. The establishment of the WUAs can be considered as the provision of professional personnel for the responsibility of water-related coordination at the village level. Although participation by villagers has played only a minor role, it was found that the WUAs help increase the water use efficiency, as well as reduce water use conflicts [66,67].

3. Lessons from the Practice: The Case of the Shiyang River Basin

3.1. The Case Study Area

The Shiyang River Basin (SRB) is an inland river basin located in Northwest China, where water shortages are most severe, and the management measures are changed rapidly and dramatically. The basin (Figure 1), surrounded by the Baddan Jaran Desert and the Tenggli Desert, has an area of about 41,600 km^2 and annual runoff of 1.56 billion m^3. Due to the low precipitation and intensive evaporation, irrigation plays a critical role in local socio-economic development, and water conflict is quite serious among different sections. The upper stream of the SRB is the Qilian Mountain Range. Runoff, mostly formed from precipitation and snowmelt, provides surface water and groundwater for the whole basin. In the SRB, increasing grain production to meet the demands of the growing population and alleviating poverty used to be given the highest priority. The government statistics show the irrigated area increased by 30%, grain output increased by 45%, and the total amount of water use increased by 75% from the 1950s to 2003 [68]. Many dams have been built in the upper stream and middle stream to ensure sufficient water supply on their own account, causing the surface water flowing to the lower Minqin oasis to reduce rapidly from over 500 million m^3 in the 1950s to 98 million m^3 in 2003 [68]. In response to the increasing water demand and decreasing spring flow, those downstream greatly expanded their number of tubewells to pump groundwater for the expanded irrigation demand. In Minqin County alone, the number of tubewells peaked at 14,000, accounting for about 1/3 of Gansu Province's total amount [69]. The severe water conflict among different reaches caused the serious overexploitation of groundwater and a continuous decline in the groundwater table [70].
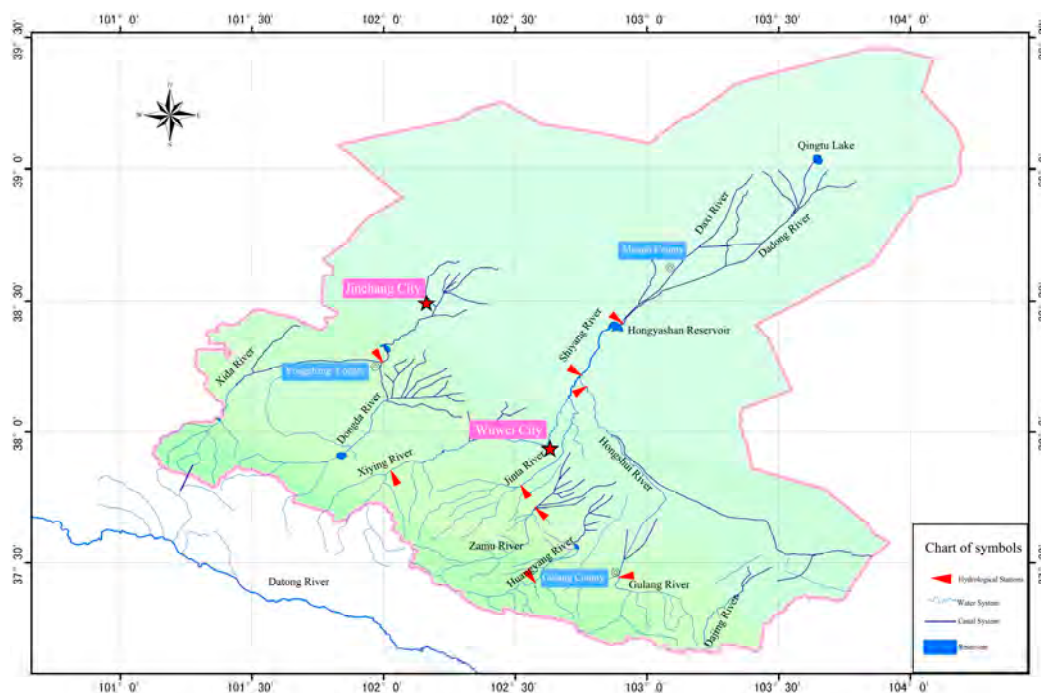
Figure 1. Shiyang River Basin, Gansu Province.

To mitigate the ecological crisis in the SRB, a unified river basin management institution, the Shiyang River Basin Management Bureau (SRMB) was set up in Wuwei in November 2001. The SRMB takes on the primary responsibility for the development of water resources (both surface water and groundwater resources) in the SRB for all purposes and is responsible for the implementation, operation, and maintenance of large-scale water projects. Furthermore, a comprehensive water management plan (CWMP) was formulated and approved by the Ministry of Water Resources in 2006 [71]. The CWMP was mostly implemented in Wuwei municipality, which occupied almost 80% of the basin's water use and 70% of the basin's area. According to the plan, water consumption within the basin needed to be reduced from the peaked 2.88 billion m^3 in 2003 to 2.13 billion m^3 in 2010 and 1.97 billion m^3 by 2020. Another important goal was to prevent further desertification and salinization in Minqin County by reallocating surface water among different reaches of the basin and limiting groundwater exploitation of these regions. It was required that surface water flowing to the downstream Minqin oasis shall increase from 98 million m^3 in 2003 to 250 million m^3 in 2010 and 290 million m^3 by 2020; groundwater exploitation in the Minqin basin needed to decrease groundwater exploitation from 517 million m^3 in 2003 to 86 million m^3 by 2020; the middle basin needed to decrease groundwater exploitation from 972 million m^3 to 822 million m^3; the whole basin needed to lessen its groundwater exploitation from 747 million m^3 to 418 million m^3 during this period.

The Gansu government recently made an evaluation of CWMP in the SRB. According to the official evaluation report, positive results have been achieved after the implementation of CWMP; all the planned objectives were realized ahead of schedule in 2014, long before 2020, and the environment started to be managed in a sustainable way by integrating the ecological restoration with advancing social and economic progress. In all these efforts, a series of water-saving policies have been implemented to encourage farmers and local leaders to adopt water-saving practices, including water consumption permits, raising water prices, investing in WSI infrastructure, and establishing WUAs. During the eight years of the CWMP's implementation (from 2007 to 2015), the official evaluation report shows that the average agricultural water-use coefficient increased from 0.53 to 0.58; water used for irrigation reduced from 1.71 billion m^3 to 1.39 billion m^3, and for per acre irrigated land, reduced from 626.72 m^3 to 430.25 billion m^3. Thus, it is of importance to examine the effectiveness of water-saving policies and the lessons that need to be learned from the SRB case.

3.2. Quota Control and Economic Incentives

To reduce the agricultural water consumption, measures relying on direct control have been widely implemented. The most important measures have been water consumption permits and reducing irrigated areas, along with the closure of tubewells. In Wuwei municipality, those included closing 3318 tubewells and limiting the water exploitation in the remaining tubewells, reducing 663 thousand mu of irrigated area, and forbidding planting high water-consuming crops, such as onions (which would consume more than 1000 m^3 per mu), corn (which would consume more than 800 m^3 per mu), and wheat (which has a low economic output per cubic meter of water). Water consumption permits were granted to individual households, which were identified by the number of people in the household and the type of crops planted. For example, in Minqin County, the permit stipulated that each person can develop no more than 2.5 mu of irrigation farmland and the water available for the farmland was 415 m^3 per mu (300 m^3 groundwater and 115 m^3 surface water). For families having farmland more than 2.5 mu per capita, they could obtain additional water use by transforming land use to greenhouses or planning horticultural crops. For example, goji and grape could obtain 250 m^3 of water use permit per mu. Another essential tool for water use control was the Integrated Circuit card (IC card) technology, with which the consumption permit could be monitored by the electronic system installed in the tubewell. The IC card was usually held by a person from the WUA board. A farmer was allowed to purchase water tickets up to 415 m^3 per mu before irrigation, and the allowed volume of water pumped by a tubewell would be the amount of irrigation farmland multiplied by the allowed permit. The IC card holder coordinated water

deliveries to his members. Farmers, together with the cardholder, supervised each other's water use time during the irrigation period, which guaranteed that irrigation water would be equally allocated. However, measures relying on direct control aroused complains. For instance, our interviewed farmers from the middle reaches were forbidden to do double cropping because their water supply had been reduced to ensure the water use in lower reaches, and farmers from the lower reaches believed that reducing the irrigated area lowered their potential incomes.

The water price has increased dramatically in the past ten years (from 2007 to 2017) in the SRB. The government of the middle reaches has increased its surface water fee for every cubic meter from 0.08 Yuan to 0.2 Yuan, while water fee in the lower reaches has been adjusted from 0.1 Yuan to 0.24 Yuan. Water fees collected in irrigation areas with groundwater only, or by mixing groundwater with surface water, would be charged by the two-part tariff system. The tariffs were divided into the basic part and the volumetric part. The basic part was a fixed fee, irrelevant from the level of consumption, which was 2 Yuan per mu. The volumetric part was charged depending on the volume of water consumed, which was 0.174 Yuan per cubic of water. Moreover, water price also differs by the cropping practices and the consumed amount. Water for greenhouses and drip irrigation would not only be exempted from the basic water fee, but also obtain a 20% and 50% discount for surface water fees and groundwater fees, respectively. For crops with high water consumption or low economic benefit, the irrigation fee would be risen by 50% for groundwater and 30% for surface water, respectively. In the case of water consumed exceeding the permit, the beyond amount would be charged at a higher rate, which is 150% for 0–30%, 200% for 31–50%, and 300% for more than 50% in excess of the allocated amount. If the water consumed was less than 90% of the allocated amount, a 10% discount would be given to the total irrigation fee. Other economic measures included: the government-subsidized 5000 Yuan per mu for greenhouse construction, 1300 Yuan per mu for wine grapes production in the lower reaches, and 300 Yuan per mu for growing fruit trees in the upper and middle reaches. Officials said those measures have encouraged local farmers to use water more efficiently and plant water-saving crops on agricultural land. The statistics from local government also showed the economic output per cubic meter of irrigation water has increased from 1.93 Yuan in 2009 to 9.33 Yuan in 2015.

The government believed that the water permit system, together with price reform, should provide conditions for the establishment of a water market. In practice, water permit trading did exist between the WUAs within the same ID, but traded less frequently (136 times comprising 9.44 million m^3 of water in 2015 and 70 times comprising 1.00 million m^3 of water in 2016). For farmers, they hardly sold their water to others within the WUA due to a lack of heterogeneity within the village, for example, the same plantation structure and same period for irrigation water distribution. At the national level, legislation and the necessary regulatory framework were still not ready to support the development of a water market. Moreover, those top-down regulations encouraged the cultivation shift from traditional grain crops to cash crops in the SRB, which substantially increased the benefit from every cubic meter of water use. Thus, farmers' average income was still doubled with the reduced water resources and increased water price. However, these successful experiences are limited in the SRB, where water scarcity is among the most critical issues on the government agenda. A higher water price will stimulate the planting of crops with higher revenues, which may hurt the nation's food security goal of achieving 95% self-sufficiency for all major grains in the short run. Hence, it is impossible for the policy-makers to increase water prices without hurting rural incomes [47] while maintaining food security [5]. Even with subsidy strategies to compensate famers' lost income because of increasing water prices, as in a pilot area of Taocheng District [72,73], there is still a significant shift in plantation structure from the traditional grain crops to the water-saving and high-value crops [74,75].

3.3. Specially-Allocated Funds

The comprehensive water management plan (CWMP) issued in 2006 itself is a major fund approved by the central government. The water crisis in the SRB was so severe that the central

government decided to intervene and provide funds for water management directly. The fund allocated to the SRB did not follow a standardized design-bid mechanism, and the central government played an active role in mobilizing basic level units. Designing funds for only one application might be the case when they caught pervasive attention from the central government. CWMP was specially designed for the SRB by MWR with a total investment of 4.948 billion Yuan. The plan used a "matching funds" method, which required that the central government subsidize a major part of the investment; the provincial government provided a certain amount of matching funds; basic-level departments also needed to give assurances to invest when applying for the project. In the case of CWMP, 4.284 billion Yuan (86.6%) were from the central government, and 0.666 billion Yuan (13.4%) were from the local governments; 3.98 billion Yuan, accounting for 80.3% of the total investment, were primarily arranged for the WSI improvement project, such as water conveyance work and subsidies for WSI techniques. According to the government report, the main achievements made from the investment included, 824 km irrigation canal was reconstructed with concrete for preventing canal seepage; 117,300 ha of irrigated land was upgraded to use pipe or drip irrigation; drought-resistant crop varieties, including Chinese medicinal herbs, fruit trees, cotton, and sunflowers were widely planted; and the number of greenhouses was considerably extended by governments' subsidies.

Other funds also have been invested in SRB to promote the WSI together with the CWMP fund. One typical example is the on-going Sino-Israel Financial Cooperation (SIFC) program in the middle reaches. The central government fully funded the project by providing approximately 3000 Yuan/mu state loans to support the demonstration of high-tech technologies. The SIFC program was designed by the National Development and Reform Commission and Ministry of Finance in 2012 with the purpose of introducing Israel's high-tech WSI technologies and promoting China's WSI development. The program stipulated that all counties from China's northwest provinces, including Shaanxi, Gansu, Xinjiang, Ningxia, and Qinghai, were eligible to apply for the fund. Our investigated government in SRB applied and did not obtain the fund until 2016. According to the government's plan, 39,600 mu farmlands in the SRB would be equipped with highly automatic drip irrigation systems imported from Israel. The drip tape was freely provided in the initial stage, and local farmers needed to purchase it afterward. Training courses were conducted by technicians from companies, and representatives of farm members were trained on how to use the equipment. With the automated irrigation system, one person could control the irrigation and fertilization for approximate 3000 mu. The program also helped reduce one-third of the irrigation water, 10% of the fertilizer, and ensured quality consistency of the crops. Nevertheless, the machine increased farmers' electronic costs, which would offset the saved fertilizer expense.

The two design-bid cases mentioned above represent the category of engineering funds and demonstration funds, respectively, which are frequently designed for the WSI. In the first case, despite great achievements having been made, our investigation found that some funds were not sufficiently used, and even caused adverse consequences because the departmental ideas or expert opinions did not always connect the practice with scientific knowledge. For example, to increase the canal water-use coefficient, an irrigation canal had been reconstructed with concrete to prevent seepage. These measures may cause the death of trees and shrubs around the canal because of the reducing seepage. In lower reaches of the SRB, the dying plants are a critical component of the shelterbelt landscape, which protects the farmland against shifting sand. Thus, the enforced WSI measures could have been more effectively implemented by considering indigenous knowledge and the local context. The second case shows the WSI demonstration program is usually of high-tech with large investment. Outside the program, villagers will hardly adopt the automatic irrigation technology without lavish government support. The replacement of irrigation pipe will be quite burdensome after the project is implemented. If some farmers are not willing to buy new pipes after the SIFC program, the high-value equipment will be abandoned. Moreover, farmers have only been trained for how to use the machine. If some parts of the machine do not work, they are unable to fix it in time. This kind of problem has crippled many other similar projects

because of the deficiency of after-funding services. Thus, overemphasizing the highly-advanced technology might be far beyond China's current small holder's stage and raises the problem of sustainability and replicability. Moreover, the funded villages in the SIFC program have always been linked to other funds, such as the fund for farmland leveling, which will provide the infrastructure conditions for the SIFC program. Our investigation indicates that the Matthew effect occurs during the implementation of WSI funding polices. Villages with the experience of implementing funding programmes will be given the priority for new funding programs. The phenomena of "fund linked to funding" may cause a project-made income disparity among villages.

3.4. The Development of WUAs

In the SRB, the WUAs have been widely established since the early 2000s upon the requirement of local governments. The government statistics in 2014 showed that the WUAs were developed in 77.6% of the villages in Wuwei municipality, in which 874 WUAs accommodated 2517 managers, 308,000 households, and 2.37 million mu of irrigated farmland. The primary duties of the WUA were to help the collection of irrigation fees, to resolve water conflicts among households, to purchase water from water supplier, and to allocate agricultural water at the village level.

The WUA board in SRB, supposedly elected by villagers, was composed of one director and two deputy leaders according to the local government's requirements. During our investigation in more than 30 villages, none of the board members were elected following the procedures in establishing the WUAs and the directors of the board were normally the current or previous leaders of the villages. Moreover, the director usually took all the responsibility for agricultural water management, and the deputy leaders only assisted water allocation during the busy irrigation period. The funding sources of the WUAs included two parts: a fixed part, which is 3000–4000 Yuan provided by the county government, and a profit-sharing part, which is decided by the total water fees collected from famers, total irrigation area, and the director's performance. Those two parts would amount from 12,000 Yuan to 16,000 Yuan, and the director would receive around 70% of the total. In our interviews, the directors, also as village leaders, were quite glad to take the duties of agricultural water management. This was because they were required to stay in the village as the village leader, which enabled them to have enough time to take the responsibility as well as receive additional remuneration beyond their regular salaries. WUAs had successes in filling the vacancy for a specialized water manager at the village level. For example, the duty of taking care of the irrigation infrastructure, which used to be ignored in rural management, has been assigned to the directors of WUAs; both our interviewed government officials and villagers believed that water has been more efficiently allocated to individual farmers because they know whom to turn to if they have problems with the allocation; according to the government documents, the rate of water fee collection increased from less than 60% to over 90% and the number of water conflicts decreased from over 10 cases per village to nearly zero after the establishment of WUAs. Although water management has been improved in general, the implementation of WSI policies was carried out without consultation with, or participation of, farmers. Water use permits were pre-determined by the government and WUAs deliver government orders from the top. Our interviewed farmers attended WUA meetings mostly because they cared about the official decisions of the irrigation quota, fees, and time, rather than participating in water use decisions.

The failure of public participation in WUAs of the SRB, just as in other places in China, comes with the question: Are farmers able, or are willing to, participate in WUAs? China has a centralized tradition, and the government shall take all responsibilities. It is the government's intention, instead of the farmers', to establish the WUAs. It is the government officials' and experts' decision, rather than the farmers', of how to make use of the water resources. The purpose of empowering WUAs is only to make it easy to complete official tasks, such as allocating water use permits, promoting WSI techniques, and collecting water fees. The performance evaluation on WUAs is based on how well the government's tasks have been complemented, which has nothing to do with

farmer's participation. The formation of the WUAs becomes an effective tool for the government monitoring and controlling water use at the village level [76], rather than an open platform for farmers defending their own interest. The WUAs fail to represent the interest of their members, and the information exchanged between the government and non-state beneficiaries remains to be a one-way and top-down manner. Under the intense controlling power from the elite officials, the WUAs, as well as their members, normally have little autonomous power. On the other hand, farmers are reluctant to win them with more responsibilities and rights in water management. Our interviewed farmers expressed their inclination of relying on the authorities for irrigation management rather than self-governance. Invariably, famers do not believe that their advisory participation, such as allocating spare water to the trees and shrubs around the canal after its lining, will be considered by policy-makers. A lack of political participation consciousness makes it difficult to encourage farmers to take the extra responsibilities and costs in realizing effective self-governance. There is also a lack of incentive for participation. Farmers have more access to off-farm employment and have depended less on irrigation than before. According to the government's statistics, over 60% of the prime working age farmers migrated out of their village for off-farm employment, and the proportion of farmers' non-farm income increased from 26% in 2007 to 43% in 2015 [68,77]. This situation makes famers have less interest in running the public affairs of the village.

3.5. Discussion and Future Directions

The ecological crisis in the SRB used to be severe due to the exhaustive exploitation and non-sustainable use of water for irrigation. In the context of the national WSI policies by which to stem the rising demand for irrigation water, the water management reform in the SRB is of both success and failure in the WSI. WSI policies have been implemented by the combination of all these three management mechanisms, which involves top-down regulations through the administrative hierarchy, design-bid funding for local governments' competition, and bottom-up participation by irrigation water users. The effectiveness of the WSI management will be determined by the performance of all relevant stakeholders, including the central government, local governments, village level organization, and famers. Different WSI management mechanisms are on target for different stakeholders to convey incentives for behavioural change.

The SRB was one of the important grain producing regions in China before 2006. The inaction of the CWMP indicated that the central government relaxed the food security and agriculture development requirement in this area, with reducing agricultural water use being given the highest priority. Under the top-down mechanism, local officials' performance in the SRB was greatly evaluated by their fulfilment of water-saving duties. Mandatory WSI regulations, such as quota control and price adjustment orders, were enforced effectively by local governments. However, this was sometimes at the expense of agricultural production and famers' income, which was also the central government's concern. Although most farmers had changed their plantation to water-saving and high-value crops, they were still inclined to increase irrigation water use and expand their irrigation areas. As a result, some farmers managed to have access to more water by stealing water and colluding with local officials in charge of water use, which was reported by the local media. Moreover, there was a very large implementation gap of the top-down mechanism when comparing the SRB with other regions. This was mainly because the WSI has not been considered as a priority for most local governments, compared with other policy goals, such as ensuring food security and poverty reduction. Under the design-bid mechanism, the vertical level and horizontal scale of the institution had been restructured to adapt the task-centred mode of management. Local governments had been motivated and had the decision-making power in carrying out and organizing the grants program. At the same time, the central government gained an effective mobilizing power in the design and allocation of special funds, other than relied solely on the bureaucratic system. For non-state stakeholders, they played no role in drawing up the plan, and they were largely excluded from decision-making processes. More often than not, a lack of

communication between government and water-users obstructed the "quality" of WSI decisions. Under the bottom-up mechanism, the WUAs had been established to promote the WSI theoretically based on the participation of farmers. As an individual was chosen to be accountable for the WSI management at the village level, governments increased their controlling power over ensuring the implementation of WSI decisions. In contrast with the traditional form of leader-run management, directors in the WUAs were paid a bonus based on their performance, thus faced with better incentives. For farmers, fewer efforts had been made to encourage their participation in the management.

As demonstrated above, the managerial incentives created by the management mechanism reform led to the consolidation of government authority. However, too much government control and the near-absence of famers' participation affect the ability to deliver high quality WSI policies and to improve the implementation and compliance. The current management mechanisms tend inevitably to devolve into "trade-off of money and water-saving", where all relevant stakeholders attempt to pledge economic interests instead of pledging the consensus of public interest. The WSI management is faced with the risk of frangibility in the case that an external disturbance occurs, such as the government's budget reduction, climate change, and free-riding chances. Clearly, if policy-makers want to better solve China's water crises in water-scarce areas, additional policies will be required to better align stakeholders' incentives. Indeed, there are cases where farmers may have greater incentives than government agencies to ensure the effective water conservation, such as in the cases in Nepal [78], the Philippines [79], and Bali [80]. Implications derived from those cases indicate that a reliable and robust WSI management should be community-based with external assistance needed to be provided upon a request of the community. It is vital to mobilize water users participating in the process of establishing WSI rules, and to ensure that their implementation, as well as supervisory practices, is user-motivated, other than external controls from the performance-based management system. A future management reform should focus on bringing meaningful water users' participation for the improvement of decision-making process. Those include the shared perception of environmental problems by water users and government officials, the collective monitoring of mutual accountability, and the establishment of trust for designing rules, so as to promote cooperation and to resolve the conflict of interest among different stakeholders [5,40,44,64,78–81].

4. Conclusions

To feed the increasing population under the conditions of keeping sound ecosystems and environment, there is an urgent need for China to produce more food with less water, which makes the effective WSI management more critical. For saving irrigation water, China has changed its management from the supply-side to demand-side by a range of institutional arrangements and policy goals. Nevertheless, the fragmented bureaucratic responsibilities led to conflicts between upper-level and lower-level agencies, as well as between government and water users, which undermines the enforcement of WSI policies. In response to the growing managerial conflicts, this paper also explores how WSI can be achieved by highlighting the three management mechanisms. The top-down regulation mechanism, by either direct control or economic instruments, helps determine the allocation of, and the pricing strategies for, irrigation water. The design-bid funding mechanism provides an effective way to achieve the central government's WSI intension by reducing the barriers between the government's different departments and different levels. The bottom-up participation mechanism, although remaining nominal to a large extent, plays a key role in improving water management at the village level by the linkage between government and local water users. Throughout the process of WSI management, different combinations of these mechanisms have been used as an attempt for aligning stakeholders' incentives to achieve the planning objectives.

For the time of policy flux over the past decade, the implementation of WSI practices can rely on regulation, funding, and participation, with their respective advantages in mobilizing different stakeholders. However, there are challenges faced by all three management mechanisms because of the pervasive institutional and economical inefficiency and the continuing near-absence

of end-user participation. Our field research shows that a wide diversity of measures has been used during the implementation, which provides an effective method to realize WSI objectives in SRB. At the same time, there are conflicts among different policy goals, uneven distribution of fiscal resources, insufficient participation from farmers, and unchanging, if not the aggravating, authoritarianism of the bureaucratic system. Thus, the WSI management should consider providing more incentives not only to policy-makers, but also to the affected population in constructing participatory institutions and governance.

Our analysis enriches the current understanding of WSI management in China and supports the conclusion that the government should continue to support management reform. Neither the highly-bureaucratic irrigation institutional arrangement, nor the involved enthusiasm of local governments' applying for funds, nor the nominal involvement of local water users, are sufficient for successful WSI management reforms. Problems it encountered in implementation have rendered the importance of facilitating meaningful participation of stakeholders with the well-defined regulatory powers and aligned water-saving purposes. Meanwhile, different management strategies, rather than a favorite cure-all mechanism should be considered to provide WSI solutions based on the understanding of local contexts. The research findings seeking for the attainment of the sustainable WSI management can also be applied to other countries facing similar water shortages.

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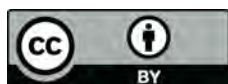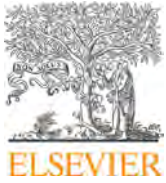
Cointegration in China's log import demand: Price endogeneity and structural change

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A B S T R A C T

The monthly data of China's log import from January 2000 to December 2013 are used to estimate the import demand elasticities, with the consideration of possible price endogeneity due to China's large share of the international log market, and structural break caused by global financial crisis in 2008. To address the possible structural break, cointegration tests allowing for a deterministic shift in the level of the variables are employed, and a two-stage estimation with top-down sequential elimination algorithm is performed on the restricted subset VECM. The results demonstrate that there exists a long-run cointegration relationship between China's log import and the explanatory variables. The import elasticities of macroeconomic development and import price are around 0.76 and −0.81, respectively. Other things being equal, the structural break would induce a 29.6% decline in China's log import. All the above parameters are significant at the 1% risk level. Furthermore, the contribution decomposition analysis suggests that China's macroeconomic development plays a dominant role in determining its log import, which implies that China's log import would not increase as quickly as before, given that its economy is shifting into the "New Normal State". This conjecture is supported by our simulations, which indicate that, by 2020, the growth rate of China's log import will be lower than it has been in the past and the import volume would be approximately 1.1–1.6 times greater compared to imports in 2013.

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Introduction

During the past two decades (1995–2015), the annual growth rate of China's gross domestic production (GDP) has ranged from 6.9% to 14.2% (NBSC, 2016). This spectacular and sustained economic expansion has also triggered a surge in consumption of logs. The scarcity of domestic wood raw material in China means that the large gap between log consumption and production must be satisfied by imports from abroad.[1] As a result, China has become the world's largest log importer since 2002. In 2015, the amount of log imports into China reached 44.57 million m³, accounting for 42.19% of world total log imports, and the share of imported logs of total consumption of logs in China increased to 39.48% (NBSC, 2016; UN COMTRADE, 2016). The shortage of domestic logs may be further exacerbated in the future. The Chinese government has launched a nation-wide policy that bans commercial logging in all natural forests, beginning in the year 2017. In the 13th Five-Year Plan, the government also reduced the country's overall harvesting quotas to 254.04 million m³ for 2016 to 2020.[2]

The scale of China's log imports is claimed to be an important cause of deforestation and depletion of forests in tropical countries, and is criticized as a menace to world's forest sustainability by the international community.[3] Given China's large quantity of

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[1] The forest cover in China is estimated at 21.63%, much lower than the average level of world, 31% of the land area. The forest area and stock per capita are 0.15 ha and 10.98 m³, around 1/4 and 1/7 of world average levels, respectively. In addition, around 73% of forests are covered with small sized trees, i.e., 6–12 cm of diameter at breast height (SFA, 2014).

[2] See Chinese Central Government (http://www.gov.cn/zhengce/content/2016-02/16/content_5041486.htm).

[3] See, for example, the Economist (http://www.economist.com/news/asia/21665030-chinese-firms-are-still-stealing-myanmars-forests-stumped), and Chatham House

imported logs and the associated continuously increasing world-wide attention on China's log imports, it is important to identify the determinants of China's log imports and to quantify their effects on the demand for imported logs. Furthermore, the possible future trend of China's log imports is an interesting question, also on the international level. The motivation of this study is that, in our opinion, this type of quantitative information based on appropriate econometric research has not gained sufficient attention in previous literature.

There is plentiful literature focusing on the price elasticity of demand for imported logs and the related product – lumber, for example, Buongiorno et al. (1979), Lewandrowski et al. (1994), Uusivuori and Kuuluvainen (2001), Turner and Buongiorno (2004), among others. These studies use either time series or panel data and can be categorized into the first stream of econometric analysis on timber imports. More recent studies using time-series data emphasize the importance of accounting for the time-series properties of the data used, employ unit root and cointegration techniques to resolve the spurious regression problems, and hence comprise the second mainstream, including studies such as Song et al. (2011), Baek (2012), Hietala et al. (2013), Nagubadi and Zhang (2013), Niquidet and Tang (2013), Parajuli and Chang (2015), Parajuli et al. (2016), Parajuli and Zhang (2016), Zhang and Parajuli (2016).[4] These studies have confirmed the crucial role of macroeconomic development, prices, and governmental policies on determining the import demand for forest products. The four most recently mentioned studies above are noteworthy, as also the structural breaks are taken into account in cointegration analysis.

The abovementioned studies concentrate on timber import in either the Nordic countries or the North America. In contrast, modeling China's forest products sector and trade has lagged behind. Indeed, the estimation of China's demand for log imports has attracted academic concerns only in recent years, and the number of studies is quite limited, as depicted in Table 1. Furthermore, different studies give inconsistent and even contradictory conclusions. For elasticities of China's import demand with respect to price and income or expenditure, both elastic and inelastic cases are reported. There seems to be variation due to different estimation methods and data sources. These varying results suggest that the relationships between China's log import and its main determinants are empirically indeterminate. Hence, further investigation of China's log import demand is well-justified in this paper. Compared to the extant literature, there are three main differences in the analysis of the present paper.

The first is related to the potential endogeneity, which is ignored by the previous literature on China's log imports. Considering the fact that China accounts for around 42% of world total log imports, it is not plausible to postulate, a priori, that China is a price-taker in the world log market (Zhang and Buongiorno, 2012). In this study, a multi-equation system is established to capture the possible bidirectional causality between import price and quantity, and the parameters are estimated with appropriate cointegration techniques. As an alternative, a single-equation dynamic feasible

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(https://www.chathamhouse.org/expert/comment/china-both-major-cause-and-potential-solution-illegal-logging). We note, however, that these critiques are mainly based on preliminary observations and subjective judgments. Whether the deforestation in other countries is a result of China's timer imports requires rigorous scientific analysis. Existing studies on deforestation indicate that deforestation in resource abundant countries is rather a result of a synthesis of numerous factors, such as weak property rights and imperfect institutions (Coxhead, 2007). Furthermore, much of China's imported timber is processed as intermediate goods and re-exported to other countries as manufactured products (Roberts and Rush, 2012).

[4] See Toppinen and Kuuluvainen (2010), Song et al. (2011) and Parajuli and Chang (2015) for literature reviews.

Table 1
Estimated elasticities of China's import demand for logs in previous literature.

Study	Data	Market/species	Model	Estimator	Elasticities	
					Price	Income/Expenditure
Michinaka et al. (2011a)	Annual 1990–2008	NZ/radiate pine	Classical	Two stage least square	−0.74	2.83***
Niquidet and Tang (2013)	Monthly Jan.2001–Dec.2011	Disaggregated/softwood	AIDS	Blundell-Robin least square	−1.17***∼−2.14***	0.75***∼3.38***
Sun (2014)	Monthly Jan.1995–Dec.2012	Disaggregated/CTO	Rotterdam	SUR	−0.00∼−2.81**	0.30***∼−5.51***
Cheng et al. (2015)	Annual 1992–2012	Disaggregated/log	AIDS	SUR	−0.48∼−4.28	0.30∼1.99

Note: NZ and CTO indicate New Zealand and coniferous, tropical and other nonconiferous logs, respectively. AIDS and SUR denote almost ideal demand system and seemingly unrelated regression, respectively. ** and *** denote statistical significance at 5% and 1% level, respectively.

generalized least square (GLS) estimator, where the possible endogeneity would be eliminated by adding appropriate orders of lags and leads is also performed to check the robustness of results obtained from the multi-equation system.

The second contribution refers to the issue of structural breaks in China's log import, which experienced a striking decline from the peak of 37.13 million m^3 in 2007 to 28.06 million m^3 in 2009 (UN COMTRADE, 2016). Existing literature has argued that China's import has been negatively influenced by the global economic recession and trade collapse around 2008 (Bai et al., 2015; Gozor, 2014; Sun, 2015). This structural break should not be neglected when investigating China's log import. However, the involvement of structural breaks may weaken the power to reject a false null hypothesis of unit root tests (Perron, 1989), and would influence the distribution of the cointegration test, distort the standard inference procedures for cointegration and may further yield to biased parameter estimations (Abadir et al., 1999). To address this issue, Johansen-Mosconi-Nielsen's cointegration test (hereafter JMN test) (Johansen et al., 2000), which is a modification of the conventional Johansen test, and the other test proposed by Saikkonen and Lütkepohl (2000) (hereafter SL test) are used in this paper, as they allow level shifts in the data. Recently, a similar framework was used in Parajuli and Chang (2015), Parajuli et al. (2016), Parajuli and Zhang (2016), and Zhang et al. (2016). However, only the JMN test is applied in these studies. Because the SL test generally has superior local power and size properties (Lütkepohl et al., 2003), we employ both JMN and SL tests to examine cointegration in China's log import demand under the presence of possible structural change. In addition, we apply a restricted subset vector error correction model (VECM), embedding a top-down sequential elimination algorithm, to obtain a well-defined model specification and more precise parameter estimates (Lütkepohl, 2005). To the best of our knowledge, this paper is the first to investigate China's log import under the cointegration framework with a structural break.

The third contribution regards the aggregated elasticities estimated in this paper. All previous studies in Table 1 focus on disaggregated elasticities of China's log import.[5] In the policy evaluation and projection, the aggregated elasticities are often useful, since the aggregated elasticity is an essential input in numerical models, such as CINTRAFOR Global Trade Model (CGTM) (Perez-Garcia et al., 1997) or Global Forest Products Model (GFPM) (Buongiorno et al., 2003). In addition, several papers listed in Table 1 that employ the monthly log import data, such as Niquidet and Tang (2013), Sun (2014), and Cheng et al. (2015), are based on the classical consumer demand theory, while the estimable model in this paper is based on the classical production theory, and the demand for log import is derived from producers' cost minimization problem (See section 2). Therefore, the abovementioned studies report the expenditure and price elasticities, while the macroeconomic driver and price elasticities are obtained in the present paper.

The remaining sections of the paper are organized as follows. The next section provides a framework of the theoretical model. This is followed by an econometric methodology, where the issue of structural break is discussed in detail. The sources and description of data are given in section 4, and the empirical results and their interpretations are presented in section 5. The penultimate section discusses the policy implications, and the conclusions are summarized in the final section.

Model specification

Referring to the model specification of Turner and Buongiorno (2004) and Michinaka et al. (2011b), the log import demand function can be obtained through the following cost minimization problem for a representative firm:

$$\begin{aligned} \min \quad & P_Q Q + P_O O \\ s.t. \quad & AQ^a O^b = Y \end{aligned} \tag{1}$$

where Q refers to China's log import quantity, while O refers to other production factors, i.e., capital, labor, etc. Both Q and O are the input factors of output, Y. P_O and P_Q refer to other input factors and the log import price, respectively. The Cobb-Douglas technology implies that the elasticity of substitution between the imported logs and other production factors is equal to 1. The first-order conditions for Eq. (1) can be used to derive the log import demand function:

$$Q = \varphi \left(P_Q / P_O \right)^{\alpha_1} Y^{\alpha_2} \tag{2}$$

The empirically estimable model corresponding to Eq. (2) can then be written in a natural logarithm form as follows:

$$\ln(Q_t) = \alpha_0 + \alpha_1 \ln(P_t) + \alpha_2 \ln(Y_t) + \varepsilon_t \tag{3}$$

where ln refers to the natural logarithm, $\alpha_0 = \ln\varphi$, $P_t = \left(P_Q/P_O\right)_t$, ε_t is the error term. In Eq. (3), we use relative prices, that is, the ratio of the log import price to prices of the other production factors. This is to eliminate Fisher's money-illusion effect (Bertrand et al., 2004). Eq. (3) indicates that the import demand of a country is influenced by two factors: manufacturing economy and import price. This setting is in line with the international mainstream model of import demand,[6] and is widely applied in estimating import demand function, such as Ozturk and Arisoy (2016), Mukherjee et al. (2017), etc. According to the theoretical expectation, price elasticity α_1 should be negative, while the economic output elasticity α_2 should be positive.

Economic time-series are typically featured by piecewise or broken functions (Lütkepohl et al., 2003). For the case of this paper, the span of data analysed covers the global financial crisis of 2008. According to Fig. 1, there is a significant decrease in the volume of China's log imports after year 2008. Therefore, we introduce a step dummy variable ($D08$) into Eq. (3) to represent the possible structural shift around 2008.[7]

In addition, one official Chinese public holiday will be considered, namely the Spring Festival (Chinese New Year), which lasts for seven consecutive days. Many studies have stressed the importance of considering the effect of holidays when dealing with China's monthly data (e.g., Bai et al., 2015). It can be seen from Fig. 1 that the quantities of imports decrease during holiday months. To capture this effect, another dummy variable (DSF) is introduced into Eq. (3), where $DSF = 1$ if the holiday of the Spring Festival occurs in that month,[8] and the effect of these dummy variables is expected to be negative. Therefore, Eq. (3) can be re-written as follows:

$$\ln(Q_t) = \gamma_0 + \gamma_1 \ln(P_t) + \gamma_2 \ln(Y_t) + \gamma_3 D08_t + \gamma_4 DSF_t + \mu_t \tag{4}$$

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[5] There are two types of import demand function, viz., aggregated and disaggregated one. In this paper, the former is used and it is based on China's aggregated data of log import, without considering the countries of origin. Disaggregated demand function distinguishes the countries of origin where the logs come from. The aggregated and disaggregated elasticities correspond to these two types of demand functions, respectively.

[6] As noted by Hong (1999), "import demand in a market economy can be fully modelled by two determinants: income and relative prices. The other factors can all be subsumed within these two factors, at least theoretically".

[7] Herein, the variable $D08$ is not defined, since it is not reasonable to subjectively select the timing when the structural change occurs. In section 5.1, the ZA test and the LLC test are conducted, where the timing of structural change is endogenously determined. Hence, the variable $D08$ is defined based on the tests results in section 5.1.

[8] The date of Chinese Spring Festival is determined by the lunisolar Chinese calendar, and is changeable along with years. Usually, it falls on either January or February.
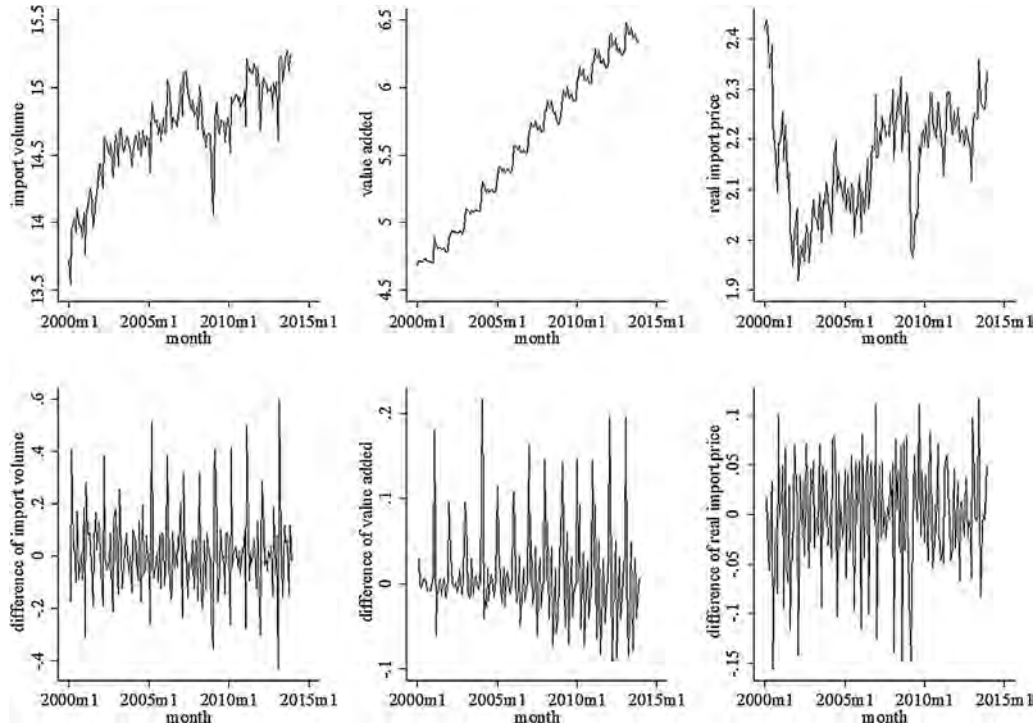
Fig. 1. Time series plots of the log-transformed variables.

Methodology

Unit root test

Under the presence of structural breaks, conventional unit root tests (e.g., ADF, PP, KPSS, etc.) are not valid. They ignore the existence of level shifts and this may weaken the power of rejecting a false null hypothesis of a unit root (Perron, 1989). Therefore, the Zivot-Andrews (hereafter ZA) test (Zivot and Andrews, 1992) and the Lanne-Lütkepohl-Saikkonen (hereafter LLS) test (Lanne et al., 2002) are employed to take into account the possible level shifts. Both of these tests can endogenously determine the timing of the structural breaks in the data.

Cointegration test

Structural breaks can affect the distribution of cointegration tests, distort substantially standard inference procedures for cointegration, and may also result in biased estimators (Abadir et al., 1999). In the present paper, we use two common tests suitable for testing cointegration among variables with level shifts. The first method is the JMN test, proposed by Johansen et al. (2000). Without loss of generality, the case of one single break point without trend breaks is considered here. For an n-dimensional time series y_t, the VECM representation is followed by (Lütkepohl et al., 2003):

$$\Delta y_t = \Pi^0 y_{t-1}^0 + \sum_{j=1}^{p-1} \Gamma_j \Delta y_{t-j} + \sum_{j=0}^{p-1} \varphi_j \Delta d_{t-j} + \eta_t, \quad t = p+1, p+2, \cdots, T \quad (5)$$

where $\prod^0$ and Γ_j are unknown $(n \times n)$ matrices, and $y_{t-1}^0 = \left[y_{t-1}', 1, -d_{t-1} \right]'$.[9] The white noise term η_t satisfies the usual classical conditions, and Δd_{t-j} is the corresponding impulse dummy which is one at T_{1+j} and is zero otherwise. JMN proposes a likeli-

hood ratio (LR) or trace statistic to test the null hypothesis imposed on the rank of matrix $\prod^0$ as follows:

$$LR_{JMN} = (T-p) \sum_{j=r_0+1}^{n} \log\left(1 + \hat{\lambda}_j\right) \quad (6)$$

where r_0 is the prespecified rank in the null hypothesis, and $\hat{\lambda}_j's$ are the ordered eigenvalues obtained from solving the corresponding generalized eigenvalue problem based on the above VECM (Johansen et al., 2000). Compared to the conventional Johansen cointegration test in the situation of no breaks, the JMN test extends it by including additional dummy variables in the long-run cointegration equation and short-run dynamics into VECM to take into account the possible effect of an exogenous impulse.

The alternative approach is the SL test. Saikkonen and Lütkepohl (2000) propose to subtract the estimated deterministic term from y_t, which yields $\tilde{x}_t = y_t - \tilde{\beta}_0 - \tilde{\beta}_1 d_t$, where $\tilde{\beta}_0$ and $\tilde{\beta}_1$ are feasible GLS estimators. The counterpart of the VECM of $\tilde{x}_t$ can be written as follows:

$$\Delta \tilde{x}_t = \Pi \tilde{x}_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta \tilde{x}_{t-j} + e_t \quad (7)$$

Then the LR statistic can be computed in the usual way through solving the generalized eigenvalue problem based on Eq. (7), which is given as follows:

$$LR_{SL} = (T-p) \sum_{j=r_0+1}^{n} \log\left(1 + \tilde{\lambda}_j\right) \quad (8)$$

where $\tilde{\lambda}_j's$ are the eigenvalues corresponding to Eq. (7). Although both of the above tests fall into the framework of the LR test, the difference between the JMN test and the SL test is that the LR principle is applied to the adjusted series in the SL test, which generally has superior local power and size properties (Lütkepohl et al., 2003). That is the reason why the JMN and SL tests are called "LR test" and "GLS-LR test", respectively, in Lütkepohl (2005).

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[9] The definition of y_{t-1}^0 follows that in Lütkepohl et al. (2003), where $\Pi^0 = \alpha[\beta' : \eta : \theta]$, hence $\Pi^0 y_{t-1}^0 = \alpha(\beta' y_{t-1} + \eta - \theta d_{t1})$. The expression in the parenthesis is the cointegration equation including the structural shift.

Parameter estimation

If the JMN or SL test suggested cointegration, then according to Pesaran and Pesaran (2010), the VECM, associated with Eq. (4), can be established as follows:[10]

$$\Delta z_t = -\bar{\Pi}\bar{z}_{t-1} + \sum_{i=1}^{p-1} \bar{\Gamma}_i \Delta z_{t-i} + \bar{a}_0 + a_1 DD08_t + a_2 DSF_t + \upsilon_t \quad (9)$$

where $z_t = (Q_t, P_t, Y_t)'$ is the vector of I(1) variables, and $\bar{z}_{t-1} = \left(z'_{t-1}, D08_{t-1} \right)'$. $\bar{\Pi} = \alpha\beta'$ is a matrix, where β is the matrix of long-run coefficients and α is the matrix of adjustment parameters. Thus, the step dummy variable, $D08$, is now a part of the cointegrating vector, and the cointegration relationship may contain a structural break. Differenced variable $DD08$ is an impulse dummy to capture the possible short-run effects of structural changes in the market, which implies that both the shifts in long run and short run can be investigated in the above framework.

Different procedures are available to estimate the long-run cointegrated parameters and short-run dynamics in Eq. (9). As argued by Lütkepohl (2005), "when the lag order and the cointegration rank of a VECM have been determined, specifying further restrictions may be useful to reduce the dimensionality of the parameter space and thereby improve the estimation precision". Therefore, a restricted subset VECM is investigated in this paper, and a two-stage (hereafter TS) estimation approach, proposed by Lütkepohl (2005), is employed to impose the structural and subset restrictions. Briefly, the TS estimator expands the applicability from a reduced form to a general form of a VECM, and is characterized by allowing each equation to have different right-hand side variables. In the first stage, the cointegration matrix β is estimated by Johansen's RR procedure or by a simple two-step (S2S) method,[11] then in the second stage, the estimated β matrix is substituted for the true one, the subset restriction is determined by specified sequential elimination of regressors strategy, and the structural effect is captured through the GLS estimator (Lütkepohl, 2005; Lütkepohl and Krätzig, 2004).

Also, the dynamic ordinary least square (DOLS) model is estimated in this paper (Stock and Watson, 1993).[12] It generates unbiased estimates, even with endogenous regressors, where the issue of endogeneity bias is corrected through the inclusion of lag and lead terms of first differences of the regressors, making its error term independent of all past innovations in the stochastic regressors. According to Stock and Watson (1993), the DOLS model corresponding to Eq. (4) is specified as follows:

$$\ln(Q_t) = \theta_0 + \theta_1 \ln(P_t) + \theta_2 \ln(Y_t) + \sum_{j=-L}^{L} \lambda_j \Delta \ln\left(X_{t-j}\right) + \theta_3 D08 + \theta_4 DSF + \zeta_t \quad (10)$$

where X is a vector containing two elements: P and Y. Akaike information criterion (AIC) and Schwarz criterion (SC) are employed to determine the optimal length of lags and leads. Furthermore, if autocorrelation of disturbances is present in Eq. (10) (which is the case of this paper), the dynamic feasible generalized least squares (DFGLS) model can be applied to correct the serial correlation (Nowak-Lehmann et al., 2012). In practice, the Prais-Winsten procedure is conducted in the iterative scheme of this paper.

Data sources and description

The monthly data, ranging from January 2000 to December 2013, for China's log import quantity and value are obtained from China Customs, corresponding to No. 4403 in the Harmonized System, with measurement units in m³ and US dollar (USD), respectively. To obtain the log import unit value (P_Q), import value of logs is divided by import quantity, which is then converted into the import price in Renminbi (RMB) using the exchange rate.[13] Following Turner and Buongiorno (2004) and Michinaka et al. (2011b), the producer price index (PPI) is employed to reflect the price level of other input factors (P_O). Hence, the relative price index (P) is obtained through P_Q/PPI, which can also be characterized as the real price index. Regarding the economic output variable, Y, the industrial value added index (VA) is applied as an approximation.[14] The monthly data of PPI and VA are released by the NBSC (2016), both of which are measured with 1999 as a base year. The holiday schedule of the Spring Festival is announced by the Central Government of China every year.

All the variables apart from the dummies are transformed into natural logarithms, as presented in Fig. 1, where the level and first difference of the variables are plotted. It can be found that there is a prominent drop in China's log import around 2008 until 2011, after which the import volume gradually recovers into the pre-crisis level. In addition, in almost every year, the log import and value added decline apparently around the Spring Festival, which suggests introducing the dummy variable to capture the festival effect. Although influenced by the financial crisis, the value added generally keeps a growing trend during the whole sample period. In contrast, the real import price presents a feature with more fluctuation and volatility.

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[10] The VECM of Eq. (4) is $\Delta z_t = -\bar{\Pi} z_{t-1} + \sum \bar{\Gamma}_i \Delta z_{t-i} + a_0 + a_1(D08)_t + a_2(DSF)_t + \upsilon_t$, $i = 1, \ldots, p-1$. According to Pesaran and Pesaran (2010), a restriction of $a_1 = \bar{\Pi} b_1$ is imposed on the coefficient, where b_1 is arbitrary vectors of fixed constants, to ensure the solution of the model in levels of z_t will not contain cumulative effects of structural change indicators. Plugging the restriction into the above equation yields:

$$\begin{aligned} \Delta z_t &= -\bar{\Pi}(z_{t-1} - b_1 D08_t) + \sum \bar{\Gamma}_i \Delta z_{t-i} + a_0 + a_2(DSF)_t + \upsilon_t \\ &= -\bar{\Pi}[z_{t-1} - b_1(D08_{t-1} + DD08_t)] + \sum \bar{\Gamma}_i \Delta z_{t-i} + a_0 + a_1 + a_2 DSF_t + \upsilon_t \\ &= -\bar{\Pi}[z_{t-1} - b_1 D08_{t-1}] + \sum \bar{\Gamma}_i \Delta z_{t-i} + a_0 + a_1 + a_1 DD08_t + a_2 DSF_t + \upsilon_t \\ &= -\bar{\Pi}\bar{z}_{t-1} + \sum \Gamma_i \Delta z_{t-i} + \bar{a}_0 + a_1 DD08_t + a_2 DSF_t + \upsilon_t, \end{aligned}$$

where $\bar{\alpha}_0 = \alpha_0 + \alpha_1$, $DD08_t = D08_t - D08_{t-1}$.

[11] The S2S estimator is also a kind of two stage approach, but it is not the same as the TS estimator. Briefly, the S2S estimator is only applicable for the reduced form of VECM, i.e., without restrictions on short-term dynamics. Furthermore, the S2S estimator is actually involved as one part of the TS estimator, since in the first stage of the TS estimator, the cointegrated vector β is estimated by either S2S or Johansen's RR procedure. With regard to the algorithm, the S2S estimator is featured by twice OLS estimation in the first and the second stage, while the TS estimator refers to S2S or RR procedure in the first stage and the GLS estimation is usually applied in the second stage. See Lütkepohl and Krätzig (2004) for more technical details of the S2S procedure.

[12] Based on Monte Carlo simulation, Stock and Watson (1993) find that DOLS performs better and yields lower root-mean-square error than Johansen's estimator, especially in small samples. However, as a single-equation method, DOLS is based on a hypothesis that only one cointegration equation exists. Just as Stock and Watson (1993) argue, "no single estimator is a panacea". Although, our main interests are on the multivariate estimations, we also employ the DOLS to check whether the results from multivariate estimators seem robust.

[13] The FRED database of the Federal Reserve Bank of St. Louis (https://fred.stlouisfed.org/categories/15).

[14] Housing starts is the widely used indicator as a proxy for economic activity (Baek, 2012; Buongiorno et al., 1979; Nagubadi and Zhang, 2013), which, however, is unavailable for China at monthly level. Moreover, the GDP has also been used as a proxy in previous studies (Michinaka et al., 2011b; Turner and Buongiorno, 2004). The dominant component of China's GDP is manufacturing, so-called "industrial value added (VA)" by the National Bureau of Statistics of China. It shows that the annual VA has approximately accounted for about 40% of China's GDP in the past 10 years, while the two indicators have maintained a similar growth trend and the correlation coefficient is 0.9985 (NBSC, 2016). Given that the monthly GDP is unavailable and the close relationship between GDP and VA, the monthly VA is used as a proxy of Y variable. Furthermore, according to Eq. (1), Y should refer to the output of all related industries where logs are utilized as one of the inputs. In 2012, China's sawmill industry revenue was mainly made up of four sources: furniture manufacturing, construction in real estate market, transportation and others, with an estimated share of 45%, 28%, 12% and 15%, respectively (IBIS, 2012). Hence, logs are not only related to forest industry's output, which confirms that this type of approximation is reasonable.

Table 2
Unit root test with structural break.

		ZA			LLS		
		T_b	Lags	Statistic	T_b	Lags	Statistic
ln_Q	Constant	2008.5	3	−4.594	2009.3	3	−2.476
	Trend	2008.5	3	−4.394	2009.3	3	−1.261
ln_Y	Constant	2005.1	1	−6.407***	2004.2	12	0.039
	Trend	2007.1	1	−6.787***	2004.2	12	−1.024
ln_P	Constant	2006.8	1	−4.655	2009.3	1	−1.305
	Trend	2002.8	1	−4.825	2009.3	1	−1.782

Note: T_b denotes the endogenously determined time of break by the data. The null hypothesis is the time series is a unit-root process with an endogenous structural break. For the ZA test and the LLS test, the optimal lags are selected based on the SC and the Hannan-Quinn criterion, respectively. The critical values of the ZA (LLS) test including intercept are −5.34 (−3.48) and −4.80 (−2.88) at a 1% and 5% level, respectively, while in the case of both intercept and trend term included, the corresponding critical values are −5.57 (−3.55) and −5.08 (−3.03) at a 1% and 5% level, respectively. *** denote rejection of the null hypothesis at the 1% significant level.

Table 3
The JMN and SL cointegration rank tests with structural break.

r	Model II		Model III		Model IV		Model II	
	LR_{JMN}	p-value	LR_{JMN}	p-value	LR_{JMN}	p-value	LR_{SL}	p-value
0	48.97***	0.00	83.08***	0.00	36.08***	0.01	23.74*	0.06
1	25.80**	0.03	29.99**	0.03	15.09*	0.06	10.75*	0.09
2	3.06#	0.88	7.09	0.46	N.A.	N.A.	2.38	0.15

Note: # denotes the first time when the null hypothesis is not rejected at the 10% significant level. *, ** and *** denote rejection of the null hypothesis at the 10%, 5% and 1% significant level, respectively. r indicates the hypothesized number of cointegrated equations. N.A. stands for not applicable.

Empirical results

The JMulTi software (Lütkepohl and Krätzig, 2004) is employed to conduct the empirical analysis unless stated otherwise, as it allows deterministic variables in the cointegrating relationships with valid statistical inference.

Unit root and cointegration test

Results of the ZA test and the LLS test are reported in Table 2. With regard to China's log imports, it shows the endogenously determined timing of structural break occurs in either 2008 or 2009, which does correspond to the period of global financial crisis. Therefore, the dummy variable D08 in Eq. (4) is set to 0 before 2008 and is 1 after 2008. A contradictory result can be found with regard to the macroeconomic variable, where the ZA test suggests that the series is stationary, while the LLS test does not reject the null hypothesis of a unit root. We assume that industrial value added is nonstationary, since this possibility cannot be ruled out in LLS test. The two other variables are nonstationary in levels. Moreover, all tests on the first differenced data reject the null hypothesis of a unit root, which implies that the series of first differences are stationary.[15] Thereby, the three variables are all integrated of order one.

To determine the optimal lag length of Eq. (9), the corresponding vector autoregression (VAR) model is estimated. Since monthly data are employed, the maximal lags are set to twelve. It is found that the SC suggests that the number of optimal lags to be two in VAR, while AIC suggests twelve lags. When using two lags suggested by SC, the VAR(2) residuals turn out to be autocorrelated and the lag order may be too small leading to size distortion for the test (Lütkepohl and Krätzig, 2004). On the other hand, if twelve lags are used, the loss in the degrees of freedom may result in power reductions in the tests (Lütkepohl and Krätzig, 2004). Thus, we need to deal with a tradeoff between introducing too many lags and autocorrelation. To address this issue, we employ the proposal by

Lütkepohl and Krätzig (2004), where the order is chosen "with the help of order selection criteria, sequential tests, and model checking tools", instead of direct use of the information criteria itself. Briefly, we start from the SC suggested lags of order two, then expand the VAR(p) to VAR(p + 1) one lag at the time, apply the top-down (TD) sequential elimination algorithm to delete the variables and lags that are not helpful to improve the information criterion,[16] and finally check the VAR(p + 1) diagnostic tests. Using this procedure repeatedly, we found the specification of VAR(5) to be appropriate and well-behaved.[17]

There are five distinct model specifications to be used in cointegration tests, depending on whether an intercept and/or a trend term enter the short-run and/or long-run equation (Hansen and Juselius, 1995). However, the first and the fifth specification are quite unlikely in reality or hard to be interpreted, and they are not considered in the present paper. Among the remaining three model specifications, the Pantula principle[18] is used to simultaneously determine the cointegration rank and the correct specification of deterministic components (Ahking, 2002; Demetrescu et al., 2009). With the setup of VAR(5), the results of the cointegration rank tests are presented in Table 3. The null hypothesis is for the first time not

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[15] The tests of the first difference are not reported here for the sake of brevity, but are available upon request.

[16] As a sequential elimination algorithm, the top-down approach starts from the last regressor in the equation and works down gradually to check if deleting it can reduce the value of information criterion. If so, the regressor will be eliminated. Then the second last regressor is checked, repeating the above step and so on. In JMulTi, it can be implemented through "Subset Restrictions" specification. See Lütkepohl (2005) for technical description.

[17] The portmanteau test shows there is no autocorrelation with lag orders from one to eleven (the Q statistic and the adjusted Q statistic are 95.65 and 98.98, with p-value of 0.14 and 0.10, respectively). The Jarque–Bera test implies the residual of log import equation is normally distributed ($\chi^2(6) = 0.34$ [p-value = 0.84]). The multivariate ARCH-LM test suggests there is no ARCH in residuals ($\chi^2(432) = 404.59$ [p-value = 0.82]).

[18] This involves the estimation of the three alternative models moving from the most restrictive hypothesis to the least restrictive one. The model-selection procedure then compares the trace test statistics to the critical value at each stage, and stops where the null hypothesis is not rejected for the first time (Hansen and Juselius, 1995). It is worth noting that, based on Monte Carlo simulation, Hjelm and Johansson (2005) find in some cases, the Pantula principle may not be a reliable procedure. Therefore, they propose a modification of the Pantula principle, and suggest "If the "Pantula principle" chooses Models 2, 4 or 5, accept the result."

Table 4
Summary of VECM and diagnostic tests.

	Long-run coefficients			Short-run coefficients	
	TS: 1st = Johansen	TS: 1st = S2S		TS: 1st = Johansen	TS: 1st = S2S
ln_Q	1.000	1.000	ECT_{t-1}	−0.289***(0.057)	−0.301***(0.059)
ln_Y	−0.729***(0.086)	−0.763***(0.084)	DSF	−0.268***(0.029)	−0.265***(0.029)
ln_P	0.752**(0.302)	0.808**(0.294)	DD08	N.A.	N.A.
D08	0.278**(0.092)	0.296**(0.090)	Δln_Q_{t-1}	−0.420***(0.067)	−0.412***(0.068)
Constant	−12.422***(0.711)	−12.351***(0.693)	Δln_Y_{t-1}	0.698***(0.157)	0.684***(0.157)
Diagnostic tests			Δln_Q_{t-2}	−0.201***(0.061)	−0.196***(0.061)
Portmanteau Q‡	104.361 [0.112]	103.516 [0.124]	Δln_Y_{t-2}	0.910***(0.143)	0.900***(0.143)
Adjusted Q	108.986 [0.064]	108.106 [0.072]	Δln_Q_{t-3}	−0.131**(0.052)	−0.127**(0.053)
Jarque–Bera†	0.020 [0.990]	0.007 [0.997]	Δln_Y_{t-3}	0.471***(0.154)	0.467***(0.153)
VARCH-LM††	398.321 [0.876]	397.807 [0.880]	Δln_P_{t-3}	0.260*(0.136)	0.260*(0.136)
Sample size	163		Δln_P_{t-4}	0.224*(0.134)	0.225*(0.134)

Note: The numbers in parentheses and brackets refer to the corresponding standard error and *p*-value, respectively. For the short-run coefficients, only the variables passed the TD procedure are reported. ‡ The number of lags of the Q and adjusted Q statistics is 12. † The Jarque–Bera statistic is based on the residuals from the log import equation. ††The VARCH-LM refers to a multivariate ARCH-LM test, and the d.f. of the corresponding chi-square distribution is 432. The cointegrated equation is in the form of $y + \beta_1 \times x_1 + \ldots + \beta_n \times x_n = 0$, hence the elasticity is the negative of the long-run coefficients reported in Table 4. N.A. stands for not applicable. *, ** and *** denote rejection of the null hypothesis at the 10%, 5% and 1% significant level, respectively.

rejected in model specification II (intercept in CE, no intercept in VAR), which suggests that model II is the appropriate specification according to the modified criteria of Pantula principle in Hjelm and Johansson (2005). Both the JMN test and SL test suggest that there exist two cointegration relationships between China's log import, domestic economic level, and import price in the long run.

Results for the log import demand model

Based on the above cointegration rank test and model selection results, the VECM in Eq. (9) can be estimated. The existence of two cointegrating relationships makes an economic interpretation of the estimates difficult (Luukkonen et al., 1999). The first cointegration vector is regarded as the basic estimation results in this paper. This is because the first eigenvector is based on the largest eigenvalue and contains the most useful information (Maysami and Koh, 2000). More importantly, Johansen and Juselius (1990) argue that the first eigenvector is of special interest, since it is most canonically correlated to the linear combination of multiple cointegrating vectors. Similar treatment can be found in previous literature (e.g., Cerra and Saxena, 2002; Dibooglu and Enders, 1995). Given the specification of VAR(5), the length of lags is set to be four in VECM. Table 4 presents the estimated parameters, normalized on log import volume.

The residual tests pass diagnostic checks, which indicate that the VECM is well behaved. Both the portmanteau Q and the adjusted Q statistic suggest that there is no serial autocorrelation with lags of order from one to twelve at the 5% statistical level. The multivariate ARCH statistic does not reject the null hypothesis of homoscedasticity. Moreover, the Jarque–Bera statistic indicates that the residual of log import equation is normally distributed. The VECM fits the historical observations well (See Fig. 2b). Comparing the estimation results of different methods (column 2 versus 3, column 5 versus 6 in Table 4), it can be found that no matter which procedure is selected in the first stage, the difference of the final estimation results are very subtle, which implies that the estimation results seem robust.[19]

Economic output has an expected statistically significant positive effect on China's log import at a 1% risk level. For every 1% increase in economic output, log imports would increase by 0.73% or 0.76%, depending on different estimation procedures in the first stage. The import price has an expected negative offsetting effect

on log import. For every 1% increase in import price, Chinese log imports would decrease by 0.75% or 0.81%. It is interesting to note that Chinese log import demand is inelastic with respect to both of the economic variables, which implies that Chinese log imports present rigid demand that is rather insensitive to prices and economic activity.

As expected, the step dummy variable cannot be excluded from the cointegration equation. All other things being equal, the financial crisis has caused China's log imports to decrease by 27.8% to 29.6%. The negative effect is significant at a 1% statistical level. This supports the conjecture that a structural change occurred around 2008, caused by the global financial crisis.[20] Plotting the error correction term (ECT) displays the effect of the structural dummy variable. In Fig. 2a, the dummy variable of 2008 is not included in the cointegrating vector, and an overt trend of decline can be found after 2008. This figure also indicates that the long-run cointegrating vector is unlikely to be stationary without a step dummy variable for structural change. Hence, the structural change should be taken into account in order to obtain a stationary linear combination for the endogenous variables, as depicted in Fig. 2b.

The adjustment parameter is around -0.30, and is significant at a statistical level of 1%. Thus, 30% of the deviation from the equilibrium is corrected in a month. In other words, the system will take three to four consecutive months (1/0.30) to restore a new equilibrium, which implies China's log market adjusts relatively quickly. In the short run, the dummy variable of the Spring Festival is negative and significant at a 1% risk, as expected, and leads to a 27% reduction in log imports during the festival month. This result is not surprising given that the Spring Festival holiday is the most important festival in traditional Chinese culture, during which most business activities cease, and the whole country celebrates a national holiday for at least seven days. The impulse dummy variable of 2008 is eliminated by the TD procedure, which implies that the structural changes due to the financial crisis of 2008 might not affect the short-run dynamics. An interesting finding is that the short-run price effect tends to reverse over time, that is, the parameters of differenced variables with lag orders of three and four have unexpected positive signs (lags of order one and two are excluded by the

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[19] Due to the subtle difference, the TS estimations with S2S procedure in the first stage are chosen as the basic results in the Abstract and Conclusion part of this paper.

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[20] We note that simultaneously with the global financial crisis, Russia introduced a 6.5% ad valorem tax on exported unprocessed wood, which was increased to 25% in April 2008 (van Kooten and Johnston, 2014). Log imports from Russia to China have decreased from 25.4 million m^3 in 2007 to 10.6 million m^3 in 2015 (UN COMTRADE, 2016). However, the effect of this tariff increase to China's log imports can be assumed to go through prices, therefore we assume that the most likely explanation of the statistically significant dummy, *D08*, is the global financial crisis.
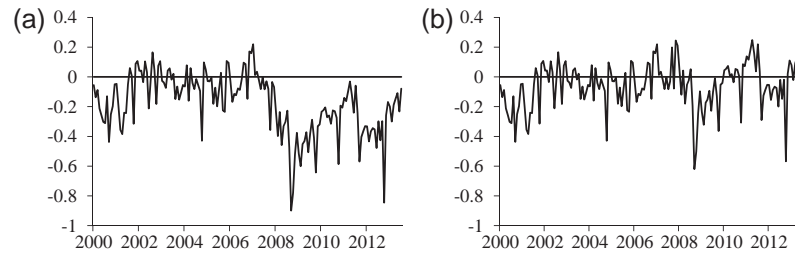
Fig. 2. a. Plot of ECT without step dummy b. Plot of ECT with step dummy.

Table 5
Long-run cointegrated parameters with DOLS and DFGLS.

	DOLS	DFGLS
$\ln\_Y_t$	0.789***(0.07)	0.746***(0.07)
$\ln\_P_t$	−0.593**(0.25)	−0.620**(0.27)
DSF	−0.248***(0.08)	−0.275***(0.03)
D08	−0.335***(0.06)	−0.263***(0.07)
Constant	11.720***(0.52)	11.988***(0.58)
Adjusted-R^2	0.86	0.96
Durbin-Watson	0.86	2.21
ρ	N.A.	0.624

Note: ** and *** denote statistical significance at the 5% and 1% level, respectively. Standard errors are given in parentheses. Based on the AIC, the optimal lead and lag length are two and four, respectively. The estimations of these lead and lag terms are not reported for the sake of brevity, but are available upon request. The heteroskedasticity and autocorrelation consistent (HAC) standard error is reported in the DOLS estimation. N.A. stands for not applicable.

TD procedure), although only significant at the 10% statistical level. The results may reflect some specific adjustment path towards the equilibrium and may be due to a correlation between the present price and expected price or some other short-run expectation or adjustment mechanism in play. Like the long-run results, the economic output also has a significant short-run effect on China's log imports.

Stability test

To investigate whether the long-run cointegrating vector remains invariant over the sample period, a procedure proposed by Hansen and Johansen (1999) is employed. This method is based on recursively-estimated eigenvalues,[21] and has been recently applied in, for example, Koukouritakis et al. (2014), Würriehausen et al. (2015). According to Fig. 3a, the recursive eigenvalues fall inside the associated confidence intervals over the whole sample. The tau statistic $\Gamma\left(\xi_1^\tau\right)$ is depicted in Fig. 3b, together with the critical value for the 5% level test, which is 1.36 in this case. The values of $\Gamma\left(\xi_1^\tau\right)$ are considerably smaller than the critical value. Thus, the diagnostic statistic does not indicate instability of the system, and the null hypothesis of the long-run parameter constancy cannot be rejected.

Alternative estimation: DFGLS

The DOLS estimator is performed on Eq. (10) and the results are reported in Table 5. It can be found that the Durbin-Watson statistic is 0.86, implying severe serial correlation. Thereby, the DFGLS esti-

mator is used to correct this issue, and the results are reported in the last column of Table 5. The parameters are all significant at the 1% or 5% statistical level. By comparing the results in Table 4 and Table 5, TS and DFGLS estimates are close to each other. For instance, the elasticity of macroeconomic level and the effect of the Spring Festival are around 0.75 and 27%, respectively, in both estimations. Regarding the structural change, both estimations support its existence, with a magnitude of around 26–29%. Regarding price, the estimated elasticity of DFGLS (−0.62) is slightly smaller than that of the TS approach (−0.75 to −0.81). Therefore, our estimations of China's log import parameters seem basically robust.

Discussion and projection

Discussion

As described in Table 1, the disaggregated elasticities of China's log import have been estimated in previous literature. For instance, Niquidet and Tang (2013) and Cheng et al. (2015) find that China's disaggregated price and expenditure elasticities for log import are greater than one with regard to the main importer countries in absolute value, implying that the weighted-average elasticity in their studies should also be greater than one, while they are inelastic in the present paper. To some extent, our findings are similar to that of Sun (2014), where the disaggregated price and expenditure elasticities of main importers are all inelastic, but the aggregated elasticities in this paper are slightly higher than the weighted-average elasticities in Sun (2014).

When comparing with the other forestry products, it is worth noting that studies on China's import demand for wood pulp and lumber (e.g., Sun, 2015; Zhang et al., 2015) suggest elastic demand with respect to the imported price and economic activity/expenditure. This difference between upstream log and downstream forestry products is consistent with the finding of Haynes (1977), who argues that stumpage demand is more inelastic than lumber demand, because the input factors are generally transformed into the product at a fixed rate.

It is worth noting that, both the TS and DFGLS estimates suggest adjacent magnitude of elasticities between price and economic output, while the signs are opposite. That raises an interesting question, that is, which factor is dominant in determining the dynamic growth of China's log imports? To address these issues, the source decomposition[22] is conducted to assess the contribution proportion of each factor to account for the biennial growth[23] of China's log import from 2000 to 2013, and the results are presented in Fig. 4. It appears that the most important source of growth is the increase

[21] In practice, the test can be performed under two VAR representations, i.e., "R-representation" and "Z-representation" as described in Hansen and Johansen (1999). In "R-representation", the short-run parameters are fixed to the full sample and only the long-run part is estimated recursively, whereas in "Z-representation", all the short-run parameters are re-estimated during the recursions. In this paper, the former one is adopted, since Hansen and Johansen (1999) remark that the results from the "R-representation" would be more appropriate in recursive cointegration analysis.

[22] Taking total differential of Eq. (4) will yield the decomposition. With annual data, the dummy of the Spring Festival must be dropped.

[23] The biennial growth rate is defined as $(y_{t+2}-y_t)/y_t$. The annual growth rate and the associated source decomposition are also conducted, whose results are very similar to that of biennial growth rate and are available upon request to authors. In our opinion, the advantage of using biennial growth rate is, Fig. 4 is more clear than
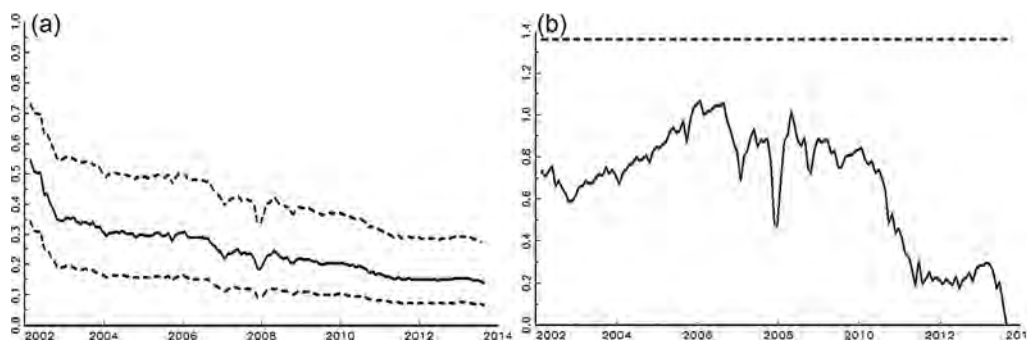
Fig. 3. a. Recursive eigenvalue and confidence interval b. τ statistic (5% test level).
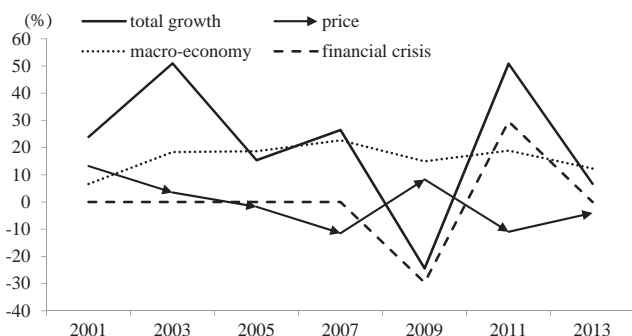
Fig. 4. Source decomposition of factors affecting log import demand in China.

of China's economic activity, while the real price has a negative contribution on log import growth in recent years, due to the rise in price. At around 2008, the lines of total growth and financial crisis appear to be consistent and almost coincide with each other, implying that the decline of China's log import around 2008 can be mainly attributed to the occurrence of the financial crisis. After the financial crisis, a high growth rate (50.83%) of log import is found in 2011, compared to 2009. However, the corresponding summation of derived growth rate from price and macroeconomy is only 7.98%. It is unlikely that this big gap is attributable to unobserved residual. A reasonable explanation is that the effect of the financial crisis weakens from 2011 onwards, such that its effect can be ignored. Thereby, when calculating the source accounting in 2011, because the base year is 2009, the financial crisis is equivalent to impose a positive effect compared to that of 2009. After including this positive effect, 73.95% of the total growth is explained, and the lines between total growth and financial crisis in around 2011 present coincident trend, as depicted in Fig. 4.

Projection

China's economy is expected to shift gears from the previous fast growth to a moderate growth in the coming years, which is called the "New Normal State" in Chinese official documents.[24] Hence, the annual growth rate of VA level is optimistically (pessimistically) assumed to be 7% (5%) in the projections (Zhang et al., 2015). The real price of China's log import during the recent 15 years has increased annually at around 2.5% on average. Therefore, +2.5% (−2.5%) annual growth (decrease) in real price of log import are used. With 2013 as the base year, the above four scenarios

are calculated up to 2020, respectively. The historical comparison between the observed log imports from 2001 to 2013 and projected log imports for the same period shows that the model basically fits China's observed log imports well.[25] By 2020, the imported quantity of log to China is predicted to be between 51.2 and 74.3 million m[3], depending on different scenarios. Hence, it can be conjectured that China will still need a large amount of logs from international markets, but the import quantities may not increase as quickly as before.

Conclusion

To investigate the determinants of China's log imports and associated elasticities, monthly data ranging from January 2000 to December 2013 are collected, and a classical import demand model, derived from production theory, is established. Given China's large amount of imports in the international log market, the endogeneity of import price is taken into account. Moreover, the possibility of structural break is considered in the model specification, since the sample period covers the occurrence of the global financial crisis around 2008. Therefore, two different cointegration tests, Johansen-Mosconi-Nielsen and Saikkonen-Lütkepohl, are employed to avoid spurious regression. The results show that both tests support the existence of the long-run stationary relationship between China's log import and its explanatory variables with a structural break around 2008.

Embedding with a top-down sequential elimination algorithm, the two-stage procedure on the restricted subset VECM is performed and the results show that China's log import is inelastic with respect to both the change of import price and domestic macroeconomic development. The long-run elasticity of price and macroeconomic level are around −0.81 and 0.76, respectively, both of which are significant at the 1% statistical level. As expected, the financial crisis imposes a negative effect of 29.6% on China's log import. Through the contribution decomposition, we find that China's log imports seem have recovered from the negative effect of the financial crisis after 2011. The short-term adjustment coefficient is significant at the 1% statistical level, and its absolute value of 0.30 implies that it takes about 3 months to restore a new equilibrium if a deviation from the equilibrium has occurred. In addition,

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that of annual growth rate, and based on it, it is easier to follow the rationale behind the figure.

[24] See Chinese Central Government (http://english.gov.cn/china_economic_new_normal/).

[25] For the sake of brevity, the actual-fitted figure from 2001 to 2013 is not reported here but is available from authors upon request. The sample used for estimation ranges from 2000 to 2013, hence the post-sample data of 2014 and 2015 provides an ideal experiment to examine whether the projection scheme works well. However, the UN COMTRADE database does not report China's log import volume in 2014. Hence, we use the data of 2015 (44.57 million m[3]) to check the comparison. It shows the projected import in 2015 is 46.80–52.06 million m[3], depending on different scenarios, which is close to the actual observation, but with some extent of overestimation. Based on this, we keep in mind that our projection up to 2020 might provide an upper bound for future outlook.

a significant festival effect is captured at the 1% level. Compared to the non-holiday months, China's log import is reduced by 26.5% during the Spring Festival.

The Hansen-Johansen test confirms that our results are stable, and the Stock-Watson DFGLS procedure suggests that our results seem robust. In addition, we find that the macroeconomic development plays the dominant role in the change in China's log import, while the import price provides a negative and offset contribution, especially in recent years. Given that China's economy is shifting from rapid growth to the "New Normal State", it can be anticipated that in the near future, China's log import would not increase as quickly as before. This postulation is supported by our forecasts, which suggests that by 2020, China's log import volume will be approximately 51.2–74.3 million m^3, or around 1.1–1.6 times of that in 2013. This moderate growth rate might be beneficial to alleviate the pressure of global deforestation, thus mitigating environmental concerns in some relevant exporting countries.

Acknowledgements

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Global Environmental Change

Complementary livelihood capital as a means to enhance adaptive capacity: A case of the Loess Plateau, China

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ABSTRACT

The sustainable livelihoods framework (SLF) highlights the positive relationship between a broad portfolio of household livelihood capitals and adaptive capacity to climate change. However, the SLF overlooks the interactions and transformations that occur between different types of capital. To test our hypothesis that complementarity-substitution exists between the five livelihood capitals, and that only increasing complementary capital can improve adaptive capacity, we assessed the adaptive capacity of apple farmers to drought events in the Loess Plateau, China. This was done through a substitutive-complementary analysis of the relationships between social, human, physical, natural, and financial capital. Using Pearson's correlation analysis, we tested the impact of 13 livelihood capital indicators on farmers' adaptive capacity. We found that some forms of capital have a substitutive effect, some have a complementary effect, and others have both. It is the overall product of these complementary indicators that increases adaptive capacity. We conclude that a substitutive-complementary approach can enhance our understanding of the role of livelihood capital in reducing farmers' vulnerability and strengthen approaches to increasing adaptive capacity.

1. Introduction

Following the publication of the sustainable livelihoods framework (SLF) (Chambers and Conway, 1991), scholars have recently begun to focus on the relationship between livelihood capital and adaptive capacity. Livelihood comprises the capacity, assets, and activities required to make a living, and assets include one's human, natural, physical, financial, and social capital (Carney et al., 1999). Different indicators are used to measure each capital type according to its definition. For example, human capital refers to personal resources, such as knowledge, health, skills, and ability, and is generally measured by educational attainment, health status, etc. Adaptive capacity, in the context of the SLF, is the capacity of a system to cope with the impacts of climate change.

The interactions between the five types of livelihood capital are complex, and many scholars simply assume they are complementary. Based on the premise of capital complementarity, it is assumed that increasing livelihood capital improves adaptive capacity. Thulstrup (2015) argues that, in the context of rural Vietnam, households with

greater livelihood capital have higher adaptive capacity, while those with less endowment and a single livelihood activity have low adaptive capacity. In a study of farmers in the Heihe River basin in China, Su and Shang (2012) found that financial capital and human capital improved farmers' adaptive capacity and reduced vulnerability to risk; further, a combination of livelihood capitals enhanced farmers' adaptability to the adverse effects of drought. Farmers with a higher livelihood capital index have more options for dealing with shocks (Su et al., 2009), and a portfolio of assets reduces climate risk and increases adaptive capacity (Moser and Satterthwaite, 2008; Zhao, 2014; Paul et al., 2016). Given that increasing livelihood capital improves adaptive capacity, some scholars have argued that the interaction of the five types of livelihood capital can be used to measure farmers' adaptive capacity. Frusher et al. (2015) defined adaptive capacity as the sum of these five livelihood capitals, while Bryan et al. (2015) and Huai (2016a) quantified adaptive capacity as the availability of livelihood capital, which, in turn, depends on farmers' capital endowments (Wang et al., 2016). Farmers' overall adaptive capacity is the weighted average of the five overarching types of capital (Singh and Nair, 2014).

However, the SLF assumes that all forms of capital are complementary and that a greater amount of overall capital leads to greater adaptability, ignoring interactions and transformations between the five asset types under certain conditions (Su et al., 2009). For example, human capital affects the ownership of other types of capital, financial capital transforms itself into other capitals, and social capital promotes the development of human capital, broadening financing channels for farmers and expanding rural livelihood capital portfolios (Xu et al., 2015; Wang and Xie, 2014). Such interactions cast doubt on the assumption that increasing capital improves adaptive capacity. Paul et al. (2016) found that, in the Ethiopian context, social capital seldom moderated the adverse effects of climate change. Further, research conducted among Australian wheat farmers (Bryan et al., 2015) found that financial capital had no significant influence on adaptive capacity. While the cost of fertilizer and soil water retention capacity reduced adaptive capacity among these wheat growers, an increase in area under cultivation and an increase in annual rainfall increased overall adaptive capacity. Tian and Chen (2014) found that financial savings increased farmers' adaptive capacity to climate change, while the consumption of financial assets reduced the funds available to farmers; for example, when the consumption of gold and silver jewelry and household appliances increased, rural households lacked of financial assets to cope with climate change.

The substitutive relationships between these five capitals challenge the SLF assumption, which is essential to understanding adaptive capacity and resilience. On the one hand, substitutions between livelihood capitals are reflected as transformations of capital investments. For example, farmers substitute financial capital for physical capital when livestock breeders use income and savings to invest in residential housing or modern poultry production units. In this instance, financial capital is reduced, but physical capital increases through investment in more lucrative activities that are less vulnerable to climate change (Alary et al., 2014). On the other hand, it is argued that investment in the assets needed to adapt to climate change cannot occur until a farmer's wealth reaches a certain threshold (Lemos et al., 2016). Other research has found that increasing investment in complementary capitals can improve adaptability. In Uganda, for example, fishermen who invest in agricultural inputs for crop cultivation and livestock farming achieve greater income and food security as well as higher adaptive capacity than fishermen who invest in gear, boats, and other fishing assets alone (Musinguzi et al., 1995). McGrath et al. (2007) found a similar increase in adaptive capacity in the Lower Amazon through complementary fishing and agricultural practices. Substitutive and complementary relationships, therefore, influence adaptive capacity when a farmer's capital portfolio reaches a level that will reduce vulnerability to climate change (Feng and Huai, 2015; Li et al., 2007).

Therefore, to accurately measure adaptive capacity and confirm the assumption that increasing capital improves adaptive capacity, we tested the hypothesis that complementarity-substitution exists between these five livelihood capitals, and that only increasing complementary capital can improve adaptive capacity. Based on a survey of 334 households in the Loess Plateau in northwest China, we used regression analysis to evaluate substitution and complementarity between capital indicators. We then used factor analysis to integrate these complementary indicators into adaptive capacity and finally identified the effects of complementary livelihood capital on adaptability. This paper contributes to existing knowledge and understanding of the selection of complementary livelihood capital to measure farmers' adaptability, thus providing a theoretical basis for climate change vulnerability assessment.

2. Materials and methods

2.1. Study area

The Loess Plateau, China (34–41°N, 98–114°E), lies in a semiarid continental monsoon climate zone, ranging from arid/semiarid to subhumid (Burnham and Zhao, 2016). The annual average temperature is 9 °C, and approximately 70% of annual precipitation is concentrated in July to September (Zhang et al., 2016). The Loess Plateau was chosen as the study site for a number of reasons. First, it is China's largest apple-producing region due to its superior natural environment for apple cultivation (e.g., high elevation, adequate light, and large diurnal temperature variations) (Liu et al., 2012). In 2013, 1.25 million hectares of land in the Loess Plateau were devoted to apple production, with a total output of 18.72 million tons. Orchard management provides the highest annual income for local farmers (Tang et al., 2013). Second, climate change seriously affects apple production. In recent decades, decreased precipitation and increased temperature have led to more frequent and severe droughts in much of the Loess Plateau (Zhang et al., 2013). Drought makes natural precipitation incompatible with the water demands of apple production, restricting the growth of apple trees and reducing apple yield and quality (Wei et al., 2010). Extreme drought events on the Loess Plateau, attributed to anthropogenic climate change, have severely hampered apple production (Li et al., 2011). Third, despite ongoing adaptations to climate change, apple farmers in the Loess Plateau face increasing livelihood challenges. In the drought of 2014, for example, 60.69% of affected households had adopted adaptive measures, such as plastic mulching, before the drought and increased irrigation and fertilizer application after the drought. However, these households were still affected by reduced incomes and threatened livelihoods (Feng et al., 2016).

2.2. Samples and data

The survey was conducted in Shaanxi, Gansu, and Ningxia in the Loess Plateau in 2015. Investigators were trained first, and then they conducted preliminary research to accurately understand the questionnaires; finally, formal interviews were conducted with the farmers (Mauger et al., 1992). A stratified random sampling method was used to select 17 apple-producing counties in Shaanxi, two in Gansu, and three in Ningxia (there are more mainly apple-producing counties in Shaanxi than in Gansu and Ningxia) (Fig. 1). The surveyed villages were determined using basic apple planting information supplied by local agricultural bureaus in each selected county. Heads or members of households in each of the surveyed villages were then contacted. A structured face-to-face questionnaire was administered to those who were willing to participate. With the help of village cadres, information was obtained regarding household socioeconomic characteristics, disaster measures, and adaptive measures for 2014. Each interview lasted approximately one hour, after which investigators checked and revised the questionnaires. Of those distributed, 334 complete and effective questionnaires were returned.

2.3. Methods

2.3.1. Measurement of livelihood capitals

This study established a household livelihood capital indicator system with 21 indicators based on the findings of previous research (Table 1) (Bryan et al., 2015; Huai, 2016a; Sharp, 2003).

Human capital represents the amount and quality of available labor (Bhandari, 2013; Su et al., 2009). Besides schooling, professional training is a way to access knowledge (Alary et al., 2014). Consequently, in addition to the educational attainment of the head of household (ED), training (TR) was classed as human capital. More common variables such as household size (HS), labor input (LI), and age of the household head (AG) were also included. As part of the quality of labor, farming experience was correlated with the number of farming years of the household head (FY) (Bryan et al., 2015). Human capital improves labor quality and farmer productivity, which can increase the rate of return on labor investment, thus improving adaptive capacity to climate change (Moser and Satterthwaite, 2008).
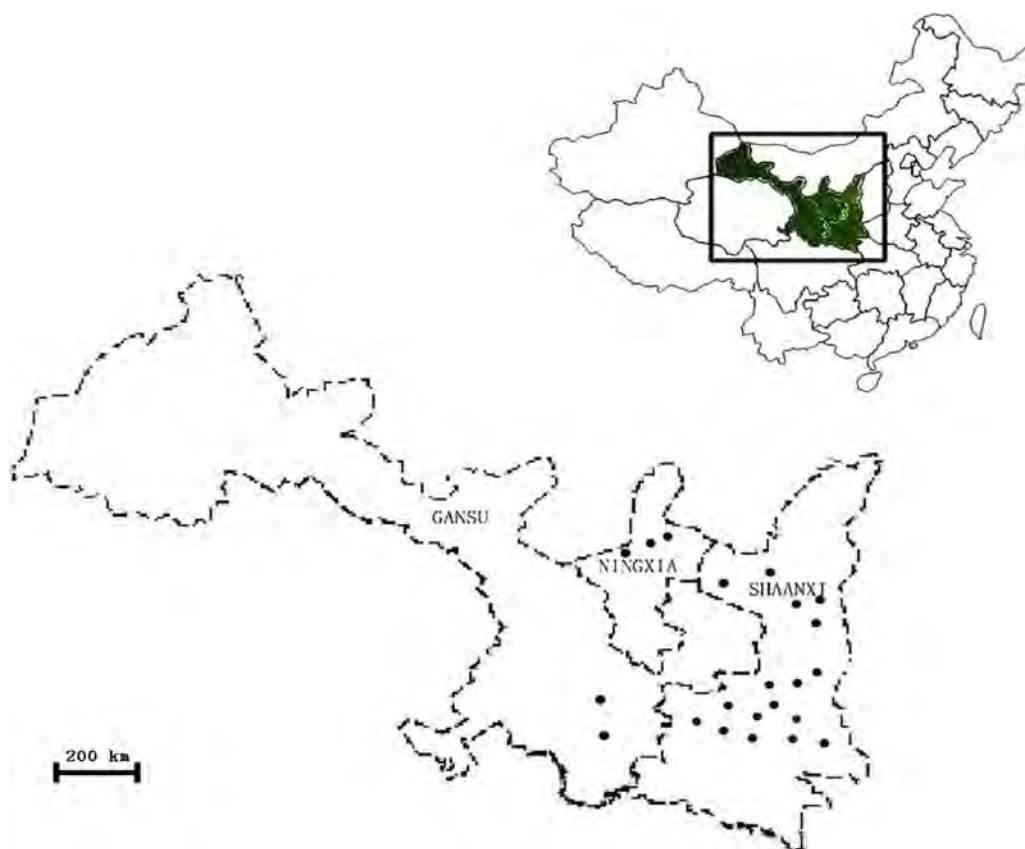
Fig. 1. Study area. Each black spot represents a surveyed county in SHAANXI, GANSU, and NINGXIA in the Loess Plateau, China.

Natural capital refers to the stock of natural resources, such as land and water (Scoones, 1998). In this survey, access to water was similar for all farmers; thus, land was the most important type of natural capital. Aside from cultivated land area (LA), land quality (LQ) and number of land blocks (NL) were assessed. The former has an impact on farmers' adaptive choices (Jain et al., 2015), and the latter reflects the degree of fragmentation of cultivated land. Under China's current land system, land fragmentation allows for intensive cultivation and increased resistance to natural risks (Zhou and Wang, 2008). Land quality and cultivated land area reflect the quality and quantity of land, respectively (Yang and Zhao, 2009), which, in other contexts, have been shown to affect land productivity (Gbetibouo et al., 2010).

The two main types of physical capital in the Loess Plateau are housing and infrastructure. Housing was measured by housing type

Table 1
Definition of capital indicators.

Category	Variable name (short forms)	Definition (unit)
Human capital (HC)	Household size (HS)	Total number of persons in the household (number)
	Age (AG)	Age of the household head (Years)
	Education (ED)	Education level of household head: 0 = illiteracy, 0.25 = primary school, 0.5 = junior high school, 0.75 = high school, 1 = university and above
	Farming years (FY)	Years of household head farming (years)
	Labor input (LI)	Percentage of time household head spent in farming (%)
	Training (TR)	Whether household numbers attended the training: 1 = yes, 0 = no
Natural capital (NC)	Number of land blocks (NL)	Number of land blocks the household cultivated (blocks)
	Cultivated land area (LA)	Total land area the household cultivated (mu)
	Land quality (LQ)	Land quality: 1 = low, 2 = medium, 3 = high
Physical capital (PC)	Housing type (HT)	Constructed types of the house: 1 = civil, wood, clay, straw; 2 = brick mixed with other materials, stone, brick kiln; 3 = brick; 4 = concrete
	Homestead area (HA)	Owner's residential area in village (m²)
	Housing years (HY)	Years that the house has been built (years)
	Current value of the house (CV)	Current value of the house estimated by the respondents (10,000 yuan)
	Distance to markets (DM)	Distance to the nearest markets (km)
	Distance to agricultural fair (DF)	Distance to the nearest agricultural fair (km)
Financial capital (FC)	Agricultural income (AI)	Household total income for all crops (main apple) (10,000 yuan)
	Nonagricultural income (NI)	Household income from nonagricultural work (10,000 yuan)
Social capital (SC)	Number of telephone contacts (TN)	Number of contacts the household head saved in telephone: 1 = 0 to 20, 2 = 20 to 50, 3 = 50 to 100, 4 = 100 above
	Number of relatives (NR)	Number of lineal relatives in three generations (number)
	Village cadres (VC)	Whether household head is village cadre: 1 = yes, 0 = no
	Time to the furthest household in a village (TF)	Time spent from home to the furthest household in a village (h)

Table 2

Results of regression analysis. The first row represents dependent variables, and the first column represents independent variables. Coefficients in italics indicate significant effects at the 1% level and the other coefficients at the 5% level. All short forms are shown in Table 1.

	HS	AG	ED	FY	LI	TR	NL	LA	LQ	HT	HA	HY	CV	DM	DF	AI	NI	TN	NR	VC	TF
HS							0.143					-0.159					0.405	-0.101			
AG				0.791													0.187	-0.331	0.121		
ED				-0.113		0.127	0.146										0.131	0.129			
FY		0.801	-0.289		0.185																
LI				0.090						0.157						0.110	-0.116				
TR	0.142		0.160				-0.125													0.126	
NL			0.154										-0.114		0.117					0.206	
LA									0.144							0.158					
LQ					0.143						0.144										
HT												-0.284	0.115								
HA	-0.142	0.091		-0.073		-0.112		0.134		-0.303			0.131			0.151					
HY													-0.178								
CV										0.104	0.127	-0.187				0.153				0.112	
DM															0.654						
DF					0.134		0.216							0.669					0.159		
AI								0.150			0.155		0.128								
NI	0.405											0.112		0.134							
TN	-0.123	-0.112	0.150			0.113						0.105			-0.086		0.101		0.265		
NR		0.070					0.144										0.101	0.241		0.112	
VC							0.210											0.158			
TF					-0.108																

(HT), homestead area (HA), housing years (HY), and current value of the house (CV). Transportation infrastructure affects access to markets. In Bangladesh and Brazil, agricultural markets, products, and prices have been shown to affect farmers' ability to diversify their livelihoods (Alam et al., 2016; Sietz, 2014). Therefore, infrastructure was measured by distance to markets (DM) and distance to agricultural fairs (DF).

Financial capital denotes the total amount of funds available to farmers (Su et al., 2016), measured by agricultural income (AI) and nonagricultural income (NI), and includes total income from agricultural activities (main apple sales) and total nonfarm income for all household members, respectively.

In China farmers share knowledge of agricultural production and expand their social capital through face-to-face, telephone, and social media communication with relatives and friends (Li et al., 2007). Social capital is the farmers' social network and associations (Paul et al., 2016) and is measured primarily by number of relatives (NR) and number of telephone contacts (TN). Social network also includes village cadres (VC) who influence access to resources and technology (Yu, 2010). The nature and intensity of social links were measured by time to the furthest household in the village (TF).

2.3.2. Empirical methods

(1) Identifying the complementarity and substitution of livelihood capitals

Scholars have generally used correlation analysis to test complementarity and substitution between indicators (Arora, 1996; Lokshin et al., 2004), where a positive relationship between indicators is considered complementary and a negative correlation is considered substitution (Braga and Willmore, 1991; Shao and Yang, 2014). However, regression can further analyze the specific dependencies between indicators (Li and Pan, 2010). Using the statistics package IBM SPSS 20.0 (IBM, 2011), this research used a regression model to test complementarity and substitution between five livelihood capital indicators:

$$X_j = \alpha_0 + \sum_{i=1}^{20} \alpha_i X_i + \mu_i \left(i \neq j \right) \tag{1}$$

where X is an indicator of livelihood capitals, i, j are the number of indicators, and μ is a random error.

Standardized regression coefficients (SRC) indicate that when independent variables increase by a standard deviation, the standard deviation of the dependent variable will change. Therefore, this study used SRC to represent the relative effects of different independent variables on dependent variables. Substitution refers to the negative influence of one indicator on another, while complementarity refers to the positive influence of both; thus, substitution indicators should be eliminated, and complementary indicators are selected to measure adaptive capacity. Given β_i, as the complementary effect of X_i: $\beta_i = \sum_{k=1}^{\ell} \alpha_{ik}$, where α_{ik} is the SRC between the complementary indicators X_i and X_k, $\alpha_{ik} > 0$, ℓ is the number of indicators that are complementary to X_i. When $\alpha_{ij} < 0$, and $\beta_i > \beta_j$, X_j is removed from the capital indicator system until no variable groups with substitution effects remain.

(2) Integrating complementary livelihood capital indicators into adaptive capacity

The factor analysis method (Below et al., 2012; Xu et al., 2008; Kolawole and Torimiro, 2005) was used to integrate complementary livelihood capital indicators into adaptive capacity. First, maximum difference normalization was used to standardize the complementary capital indicators, as follows:

$$C_i = (X_i - X_{min})/(X_{max} - X_{min}) \tag{2}$$

Second, the common factors (CF) were identified and named. Third, the contribution rate of each independent factor was used as the weight to calculate adaptive capacity (AC):

$$AC = \sum_{i=1}^{m} \left(F_i W_i / \sum_{i=1}^{m} W_i \right)$$

(3)

where F_i is the score of the common factor, W_i is the variance contribution rate of the common factor, and m is the number of common factors chosen.

(3) Testing the hypothesis that increasing complementary capital can improve adaptive capacity

Using Pearson's correlation analysis, the relationship between the portfolios of complementary capital indicators and adaptive capacity was tested.

3. Results and discussion

3.1. Complementarity and substitution between livelihood capital indicators in the loess plateau

3.1.1. Identifying complementarity and substitution between livelihood capital indicators

Positive or negative standardized regression coefficients show complementarity or substitution between capital indictors (Table 2). The results show that there are no influences on land quality, and it, in turn, has no effect on other forms of capital, indicating that land quality is neither a complementary nor substitution capital. Cultivated land area, distance to markets, agricultural income, number of relatives, and village cadres are five complementary forms of capital. For example, cultivated land area is complementary to homestead area (0.144) and agricultural income (0.158). The

remaining 14 capital indicators both complement and substitute each other. For example, age complements farming years (0.801), nonfarm income (0.187), and number of relatives (0.121) but substitutes for number of telephone contacts (−0.331).

A visual representation is needed to analyze in detail the complex relationships between livelihood capitals. In Fig. 2, capital indicators are selected for adaptive capacity, and a complementary-substitution diagram of livelihood capital is drawn using related operational

research graph theory. We argue that the capital indicators with the greatest complementary effect and least or zero substitutive effect are the most suitable for quantifying adaptive capacity. Land quality (LQ) is canceled due to its independence from other indicators. Cultivated land area (LA), distance to markets (DM), agricultural income (AI), number of relatives (NR), and village cadres (VC) are chosen because they only have complementary effect. Other indicators are then selected by comparing substitution and complementary effects (Fig. 2b). In the relatively simple relationships (Fig. 2b1), labor input (LI) simply substitutes with nonfarm income (NI) and time to the furthest household in the village (TF); however, since their complementary effects are 0.247, 0.666, and 0.00, respectively, nonfarm income (NI) is selected while labor input (LI) and time to the furthest household in the village (TF) are canceled.

In Fig. 2b2 and Fig. 3, the expected complementary effect at each decision node is calculated, and a choice is made by maximizing complementary effects. At nodes 8 and 13, farming years (FY) is selected since max {1.085, 1.04} = 1.085, where 1.085 and 1.04 represent the complementary effect of FY and NO FY (i.e., ED and HA in this instance). Similarly, farming years at node 12, training (TR) at node 9, number of land blocks (NL) at node 4, current value of the house (CV) at node 5, housing years (HY) at node 2, and household size (HS) at node 3 are selected. While number of telephone contacts (TN) is rejected at node 1 since max {2.562 + 2.127, 2.014 + 0.490} = 4.689. Nodes 11 and 4, 10 and 9, 6 and 5, and 7 and 2 are found to have the same selected indicators with the same expected complementary effect. Thus, among the indicators with the complex substitution and complementary relationships, distance to agricultural fair (DF), age (AG), household size (HS), housing type (HT), current value of the house (CV), training (TR), and farming years (FY) were chosen, and the complementary effect reached 4.689.

In summary, excluding eight indicators (i.e., ED, LI, NL, LQ, HA, HY, TN, and TF), the remaining 13 capital indicators represent a complementary capital system.
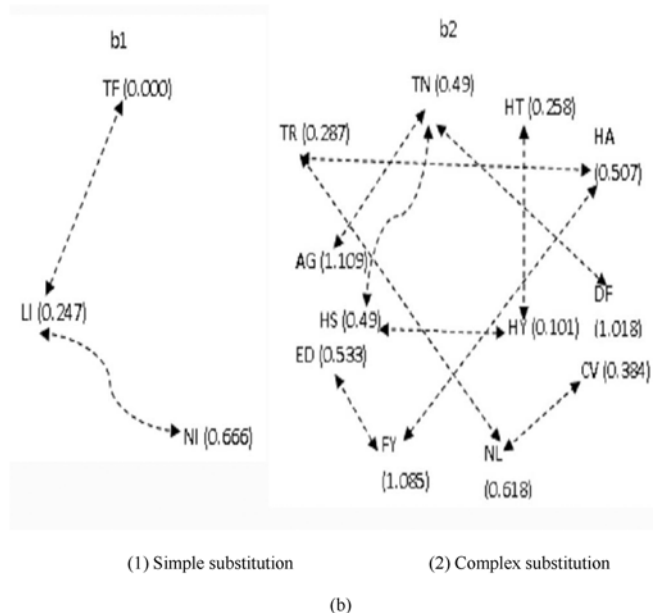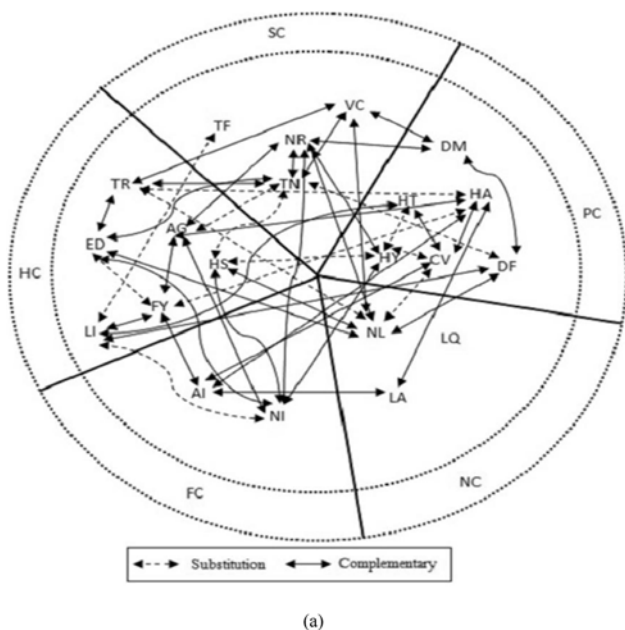
Fig. 2. Pathway of complementary-substitution capital indicators. Human, social, physical, natural, and financial capital are complementary and substitutive of each other. (a) The heavy lines divide the dotted circle into fivefans, each of which represents a type of livelihood capital and its correspondingcapital indicators. (b) The complementary effect of each substitutive indicatoris presented in parentheses. Indicators with smaller complementary effects areremoved from the capital indicator system until there are no variable groups with substitution effects.

Note: HC: human capital; FC: financial capital; NC: natural capital; PC: physical capital; SC: social capital. All short forms are shown in Table 1.

A dashed line with double arrows indicates substitution relations between capital indicators; a solid line with double arrows indicates complementary relations between capital indicators.
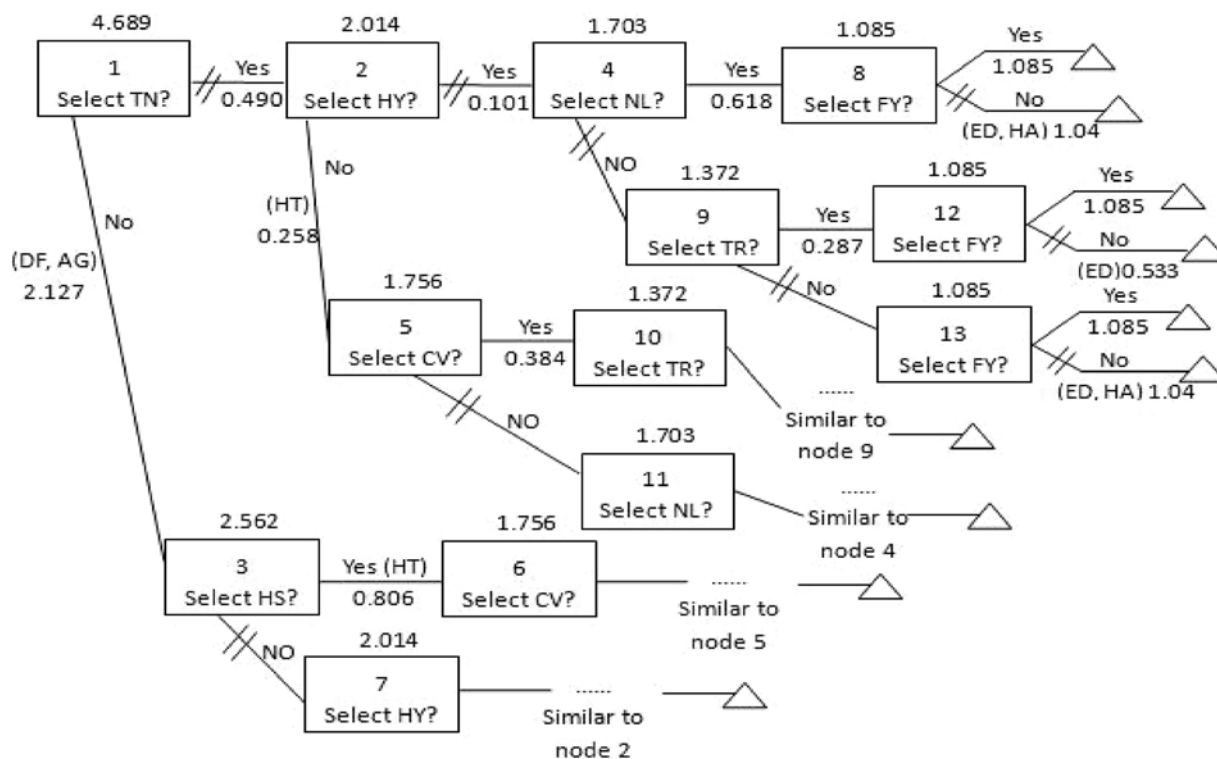
Fig. 3. A multistage decision-making tree for selecting complementary variables in Fig. 2b2. Using backward induction, we compared the expected complementary effect of different branches in each decision node and chose the branch with the largest complementary effect; the other branches were pruned.

3.1.2. Insights into complementarity-substitution between livelihood capitals in the Loess Plateau

(1) Complementary and substituted relationships occur between human capital and financial capital.

Household size, age, and education complement nonfarm income. In the Loess Plateau, the average household consists of five members. Farmers engaged in apple production are, on average, 50 years of age, while others (mainly young people) are engaged in nonagricultural labor. Household size, therefore, is complementary to nonagricultural income. Apple farmers with higher education levels have more non-agricultural work opportunities and more nonagricultural income, which supports the argument that investment in education can achieve higher potential income and that a lack of human capital limits farmers' nonagricultural employment opportunities (Djomo and Sikod, 2012; Lemos et al., 2016; Kelkar et al., 2008). Farming years complements agricultural income, as experienced apple farmers know how to apply pesticides, fertilizer, and other productive materials to improve apple yield and quality. In addition, labor input substitutes for non-agricultural income, which is consistent with research findings from India, where farmers spend more time obtaining water for agricultural production, thus decreasing both rural unskilled employment opportunities and agricultural income during periods of drought (Udmale et al., 2014). In the Ethiopian highlands, access to nonagricultural income reduces farmers' incentives to invest in agricultural conservation (Holden et al., 2004).

(2) Human capital is complementary and substitutive to natural capital.

Household size complements the number of land blocks. In China's household contract responsibility system, land allocation is dependent on household size, and many households invest in agricultural production through intensive land cultivation. Similarly, in the Loess Plateau the average per capita cultivated area is 1.83 mu (1220 m^2), divided across five noncontiguous plots within one household. Training substitutes for number of land blocks, suggesting that farmers who pursue further training know that land fragmentation can reduce

agricultural productivity (Austin et al., 2012).

(3) Financial capital is complementary to physical capital.

Agricultural income complements homestead area and current house value. A farmer's house is both a primary physical asset and a status symbol, so when apple planting results in higher income, house building or repair takes place. This finding supports the fact that when incomes exceed a critical level, farmers invest in house improvements or in increasing their physical assets (Alary et al., 2014; Udmale et al., 2014). In turn, farmers with greater physical capital (e.g., irrigation facilities and livestock) obtain higher financial capital (annual income).

(4) Social capital complements and substitutes for the portfolio of livelihood capitals.

Social networks help to increase farmers' opportunities to obtain agricultural necessities (e.g., seeds, tools, and machinery), information, and economic assistance (Abenakyo et al., 2008). Number of relatives and village cadres complement number of land blocks. Since Chinese society is based on familial relationships, when rural residents migrate away from the land, land is transferred to relatives (Yang, 2016). Village cadres have a certain right to the distribution of private plots and can take advantage of their positions to acquire more land. This is consistent with Alary et al. (2014), who found, in the Egyptian context, that natural capital and social capital are linked and complementary, and that when reclaimed land and public pastures are reduced, tribal groups also reduce in size. Number of relatives may complement non-farm income, which is supported by Zhang (2012) research in parts of the Loess Plateau-Inner Mongolia. Social capital both complements and substitutes human capital. Research in Uganda (Abenakyo et al., 2008) suggests that interactions within and between social networks promote information sharing, helping to increase farmers' knowledge and skills. This is consistent with our finding that number of telephone contacts and village cadres complement training. Meanwhile, number of telephone contacts and age have a substitution effect, as older farm laborers have fewer contacts, most of whom are relatives and neighbors.

(5) Natural capital and financial capital are complementary.

Cultivated land area complements agricultural income. Most apple

Table 3
Total variance, KMO, and Bartlett's test and meaning of factors.

Component	Eigenvalue	% of Variance	Cumulative%	Factor Label Names
Factor 1	2.023	15.558	15.558	Experience
Factor 2	1.780	13.695	29.253	Infrastructure
Factor 3	1.361	10.468	39.721	Flexibility
Factor 4	1.285	9.881	49.602	Economic resources
Factor 5	1.276	9.816	59.418	Material resources
Factor 6	1.001	7.697	67.115	Technology
Factor 7	–	32.885	100	Others
Kaiser-Meyer-Olkin measure of sampling adequacy		0.519		

Table 4
Rotated factor matrix of complementary capital indicators. All short forms are shown in Table 1.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
HS	0.013	0.030	0.821	−0.077	0.029	0.006
AG	0.935	0.053	0.101	0.046	0.034	0.002
FY	0.947	0.010	0.060	0.005	0.014	0.031
TR	−0.064	−0.087	0.055	0.025	0.047	0.880
LA	0.063	−0.024	−0.156	0.326	−0.665	−0.109
HT	0.107	0.041	−0.127	0.021	0.646	−0.153
CV	−0.039	−0.164	−0.108	0.527	0.536	−0.064
DM	−0.023	0.910	−0.002	0.065	−0.028	0.014
DF	0.084	0.881	−0.002	−0.056	0.029	0.024
AI	0.155	−0.157	−0.010	0.647	−0.177	−0.171
NI	0.144	−0.034	0.809	0.135	−0.087	−0.048
NR	−0.081	0.241	0.115	0.648	−0.009	0.142
VC	0.149	0.197	−0.145	−0.092	−0.255	0.515

farmers rely on merchants to sell their harvest, so there is little difference among farmers. Therefore, apple planting area is an important factor affecting yield and income, which is consistent with the positive relationship between land area and farmers' incomes in Guinea (Tolno et al., 2015).

3.2. Integration of adaptive capacity

3.2.1. Measuring adaptive capacity

With a combination of integration, optimization, and typology, the process of assessing adaptive capacity can be improved (Huai, 2016b). The KMO measure and Bartlett value (0.519 > 0.5), shown in Table 3, demonstrate that the complementary capital indicators are fit for factor analysis (Field, 2009). Six main factors are extracted with a cumulative variance contribution rate of 67.115% based on the principle that the eigenvalue is more than 1. Extracted factors are named based on the joint explanation of the meaning of highly loaded variables on each factor and on existing literature (Below et al., 2012). In Table 4, the first factor (F1) that heavily loads on farming years and age is labeled experience. It has been found elsewhere that experienced farmers know more about climate change and its influence and, therefore, adopt diversification strategies to reduce risk (Alam et al., 2016). Similarly, F2 is named infrastructure. F3, flexibility, mainly loads on household size and nonagricultural income. Farmers can acquire more adaptive capital using nonagricultural income, thus increasing action flexibility and adaptive capacity (Kelly and Adger, 2000), and spreading the risk across diverse sources of income. In China's main apple-producing counties, the primary agricultural activity is planting and marketing apples, which brings farmers their main income; meanwhile, nonagricultural income is smaller than the income from apple harvesting. However, nonagricultural income can provide rural households with diversified adaptation options, thus increasing flexibility in farmers' livelihoods. The main load of F4, economic resources, is on number of relatives, agricultural income, and current house value. Agricultural income is the main source of farmers' income, and loans from relatives are an important channel of informal financing (Zhang, 2012). F5 is labeled material resources. F6 has a large load on training and village cadres. Yu (2010) argues that village cadres are often at the forefront of promoting new agricultural technology and have a greater understanding of climate change risk. In the Loess Plateau, formal training for apple farmers mainly focuses on apple production and antidisaster technology. Trained farmers are familiar with alternative methods and can choose the most appropriate adaptation strategies. Thus F6 is called technology.

Therefore, farmers' adaptive capacity is attributed to experience (F1), infrastructure (F2), flexibility (F3), economic resources (F4), material resources (F5), and technology (F6). According to formula (3), farmers' adaptability index is as follows:

$$AC = 0.232*F_1 + 0.204*F_2 + 0.156*F_3 + 0.147*F_4 + 0.146*F_5 + 0.115*F_6.$$

3.2.2. Framework of farmer's adaptive capacity

Acosta et al. (2013) frame regional adaptive capacity as related to awareness, ability, and action. These three can be understood thus: when a society perceives an issue as a problem (awareness), it is able to solve the problem (ability) through a series of actions (action). These three elements comprise equity, knowledge, technology, infrastructure, flexibility, and economic power. This framework provides a perspective for assessing adaptive capacity to any kind of change, including climate change, at regional and global levels. However, it ignores differences within local scales (such as communities and households). Therefore, when applying the framework at the household level, different determinants and indicators of adaptive capacity are required to capture the rationalities of farmers' adaptive behaviors. Based on the above framework and the rotated factor matrix (Table 4), a framework of farmers' adaptive capacity was identified. In Fig. 4, awareness is represented by experience. Ability includes material ability, measured by infrastructure and material resources, and individual ability, measured by technology. Action includes flexibility and economic resources.

3.3. Effects of complementary capital indicators on adaptive capacity

At the 5% significance level, cultivated land area (LA) has a negative relationship with adaptive capacity while all others are positive (Table 5), in which age (AG), farming years (FY), and distance to agricultural fairs (DF) have the greatest impact on adaptability.

Overall, human capital is most highly correlated with adaptability, followed by physical, social, financial, and natural capitals. For agriculture-dominated households, in which more than 60% of household income is derived from apple cultivation and 80% of time is spent in agricultural activities, production skills (pruning, bagging, etc.) and materials are necessary to ensure good output. This is consistent with the argument that human capital is the core of livelihood capital, and physical capital plays an important role in influencing livelihood strategy choices (Zhao et al., 2016, 2011). It also supports the argument that well-trained farmers are familiar with the necessary approaches to adaptation and are able to choose the most appropriate adaptation strategies and new technologies to improve adaptive capacity. Conversely, poor infrastructure blocks market access, thus reducing adaptive capacity (Adger et al., 2004). Increased social capital improves the financing ability of farmers to reduce climate risk, showing that social networks promote farmers' collective adaptive behaviors and capacities (Gbetibouo et al., 2010). Financial capital can be used to purchase the material resources needed to cope with climate risks. In one of the surveyed villages, more affluent farmers drilled wells or purchased irrigation systems to adapt to drought. Natural capital, in the form of land quality, can restrict farmers' adaptability. For instance, poor land quality has negatively affects apple growth and limits apple production. In addition to apples, Loess Plateau farmers also plant wheat to feed
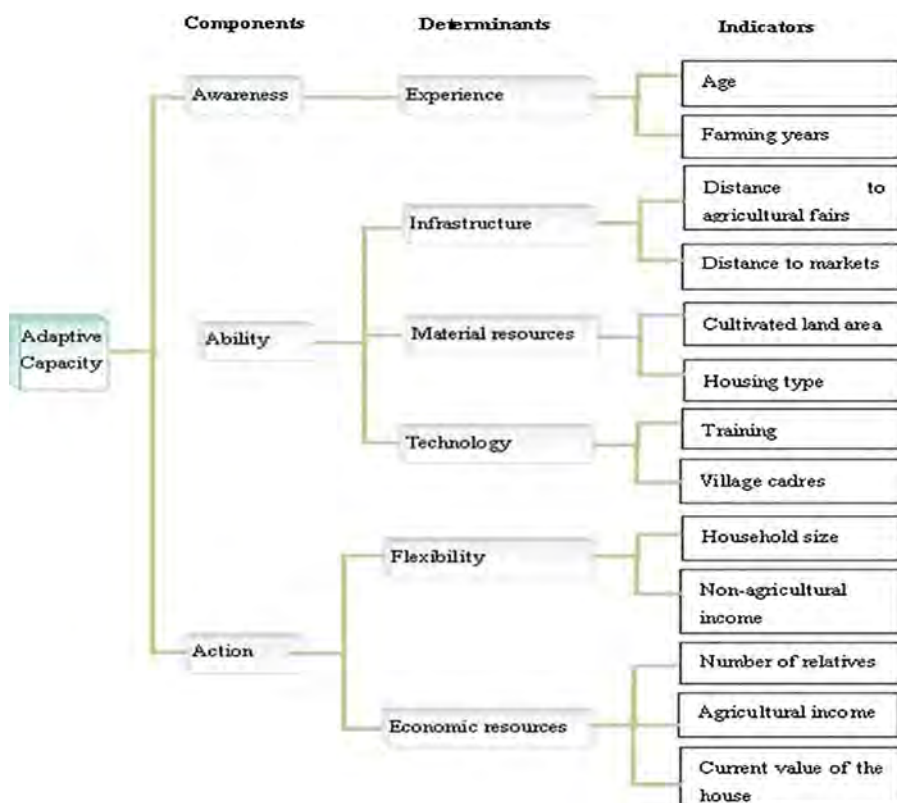
Fig. 4. Framework used to interpret farmers' adaptive capacity.

Note: All indicators are complementary livelihood capital indicators.

Source: Adapted from Acosta et al. (2013).

Table 5

Correlation between adaptability and capital indicators. All short forms are shown in Table 1.

Category	Indicator	Correlation Coefficient	Total Coefficient
HC	AG	0.609[a]	1.696
	FY	0.566[a]	
	HS	0.312[a]	
	TR	0.209[a]	
PC	DF	0.471[a]	1.351
	DM	0.446[a]	
	HT	0.222[a]	
	CV	0.212[a]	
SC	NR	0.379[a]	0.523
	VC	0.144[a]	
FC	NI	0.368[a]	0.493
	AI	0.125[b]	
NC	LA	−0.182[a]	−0.182

Note: Total coefficient is the sum of the correlation coefficients of the indicators in each capital type.

[a] Correlation is significant at the 0.01 level (2-tailed).

[b] correlation is significant at the 0.05 level (2-tailed).

their families and to sell, but clay soils in parts of this region can lead to poor wheat harvests since clay soils are easily submerged during heavy rains (Jain et al., 2015).

Among the selected complementary indicators, cultivated land area negatively affects adaptive capacity, thus refuting the hypothesis that increased complementary capital enhances adaptive capacity. This may be because we only considered linear relations and not more complex relationships (such as U-type relationships). Completely eliminating the substitution effect may be problematic, and further studies should be conducted to address this issue.

4. Conclusion

Based on testing the complementary-substitution effect between

livelihood capitals, this paper has presented the quantification and interpretation of adaptive capacity at the household level, in support of assessments of vulnerability to climate change. Complementary capital indicators were integrated into adaptive capacity to overcome the shortcomings of simply quantifying adaptive capacity by the five types of capital. Graph theory and the decision-tree method provided favorable directions for choosing complementary capital indicators. Based on a framework constructed according to awareness, ability, and action, the effect of livelihood capitals on farmers' adaptability to climate change was explained. However, owing to the many relational forms and measurement indicators in household livelihood capital systems, this paper only considered linear relations between capital indicators. Further work is needed to consider other forms of relationships between livelihood capitals to quantify adaptive capacity with fully complementary indicators.

Overall, considering the substitution and complementary relationships listed above, we can conclude that testing the relationships between livelihood capitals is a priority, and that complementary capital indicators should be integrated into adaptive capacity planning and policy making. Policies intended to enhance adaptive capacity should focus on investing in complementary and more influential capitals. For example, these findings support the argument that in China's Loess Plateau, human, physical, and social forms of capital influence farmers' adaptive capacity, while the impacts of financial capital and natural capital are relatively small. Therefore, farmers should be encouraged to invest in their human, physical, and social capital to enhance their adaptive capacity to climate change. To enhance local adaptive capacity to climate change, local governments should be encouraged to invest more in regional physical capital, such as building good highways and training farmers. Meanwhile, central governments should implement more efficient policies and laws to protect farmers' interests and establish more institutions to encourage local governments and farmers to fight climatic disaster and attain sustainable development. Nongovernmental organizations (NGOs), including scientists, volunteers, and mass media, should identify and promote complements and

substitutions, connecting different stakeholders to cooperate in adapting to climate change.

Competing financial interests

The author declare that the authors have no competing interests as defined by EVISE Publishing Group, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

Acknowledgments

Appendix A

See Table A1

Table A1
Descriptive statistics: household characteristics of survey respondents (N = 334).

Variable (short forms: units)	Minimum	Maximum	Mean	Std. Deviation
Household size (HS: number)	1.000	17.000	4.689	1.804
Age (AG: Years)	16.000	81.000	51.755	10.619
Education (ED:0 = illiteracy, 0.25 = primary school, 0.5 = junior high school, 0.75 = high school, 1 = university and above)	0.000	1.000	0.446	0.221
Farming years (FY: years)	0.000	67.000	29.897	12.423
Labor input (LI: %)	0.000	100.000	79.751	29.683
Training (TR:1 = yes, 0 = no)	0.000	1.000	0.371	0.484
Number of land blocks (NL: blocks)	0.000	20.000	4.619	3.017
Cultivated land area (LA: mu)	0.000	40.000	7.216	5.930
Land quality (LQ: 1 = low, 2 = medium, 3 = high)	1.000	3.000	2.009	0.622
Housing type (HT: 1 = civil, wood, clay, straw; 2 = brick mixed with other materials, stone, brick kiln; 3 = brick; 4 = concrete)	1.000	4.000	2.560	0.725
Homestead area (HA: m^2)	20.000	700.000	263.484	122.752
Housing years (HY: years)	2.000	62.000	16.771	10.881
Current value of the house (CV: 10,000 yuan)	0.000	100.000	14.270	10.342
Distance to markets (DM: km)	0.000	35.000	7.322	6.802
Distance to agricultural fair (DF: km)	0.000	40.000	6.193	5.761
Agricultural income (AI: 10,000 yuan)	0.000	22.050	2.732	3.583
Nonagricultural income (NI:10,000 yuan)	0.000	20.000	2.930	3.842
Number of telephone contacts (TN: 1 = 0 to 20, 2 = 20 to 50, 3 = 50 to 100, 4 = 100 above)	1.000	4.000	2.518	1.056
Number of relatives (NR: number)	1.000	30.000	8.340	5.217
Village cadres (VC: 1 = yes, 0 = no)	0.000	1.000	0.084	0.278
Time to the furthest household in a village (TF: hour)	0.000	4.000	0.473	0.496

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Assessing the decadal impact of China's sloping land conversion program on household income under enrollment and earning differentiation

CrossMark

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ABSTRACT

This study hypothesizes that the income levels of households are affected by their different areas enrolled in the Sloping Land Conversion Program, the local economic condition, and the statuses of their previous earnings. We test these relationships by running quantile regressions with data collected from 182 households in the Loess Plateau region covering the period of 1998–2011. We find that the more cropland was retired, the more subsidy was received, and the more labor was set free from farming, which, in turn, led to a larger decrease in farming income but a much larger gain in off-farm income. Further, the area enrolled had a more positive effect during 1998–2004 than that during 2006–2011 on all households; and the positive effect was significant only on those households of the 0.25th and 0.50th income quantiles later. Also, the proportion of off-farm labor to total labor, the off-farm work time, and the local GDP per capita had a larger income effect in the later sub-period, especially for households in the 0.75th and 0.90th income quantiles. These results carry major implications in terms of how to reduce poverty and increase income in ecologically fragile regions in and outside of China and how to assess the effect and effectiveness of any ecological conservation program.

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1. Introduction

In 1999, China launched the Sloping Land Conversion Program (SLCP)—the largest ecological restoration, or payments for ecosystem services (PES), initiative in the developing world (Liu et al., 2008; Bennett, 2008). The SLCP aims to reverse the country's environmental deterioration by retiring and converting degraded cropland while improving farmers' livelihoods, especially those of the rural poor (State Forestry Administration, or SFA, 2003). The program provides financial incentives to farmers who establish forest or grass cover on retired cropland in order to "supply" ecosystem services, such as reduction of water runoff and soil erosion, and prevention of flooding (Yin, 2009).

Given the substantial funding of over 300 billion yuan thus far (SFA, 2013)[1] and the broad attention that the PES program has garnered, there have been extensive assessments of the extent to which it has met its objectives (e.g., Liu et al., 2008; Yin, 2009; Li et al., 2011). While studies generally agree that the income impacts of the program vary in terms of the levels of cropland enrollment and the statuses of family earnings (e.g., Liu and Zhang, 2006; Yao et al., 2010; Groom and Palmer, 2012), it remains rare to look explicitly into the income

impacts in light of these differences. In particular, it is still unclear whether or not the poor farmers have benefitted more than proportionately from participating in the program. The goal of this paper is to address these issues by evaluating the income effects of the SLCP in a more disaggregate and nuanced manner.

Among the program practitioners and analysts, a consensus is that household income growth is an important indicator of the impact and sustainability of the SLCP (Liu et al., 2008; Uchida et al., 2007). Implementing the SLCP has both direct and indirect impacts on household income (Yin et al., 2014; Lin and Yao, 2014; Liu et al., 2010). The direct effect is reflected mainly in the government subsidies relative to the lost income from grain and livestock production. The initial duration of the subsidy was set at eight years for the period of 2001–2008, with a grain compensation of 2250 kg/ha in the Yangtze River Basin and 1500 kg/ha in the Yellow River Basin (Xu et al., 2004a). In addition, an annual cash outlay of 300 yuan/ha was universally adopted for tending and protecting the planted trees and other established vegetation covers. Due to the dwindling public grain stocks, however, since 2004 the grain compensation has been replaced with a cash payment at a constant rate of 1.4 yuan/kg (Xu et al., 2004a). To continue the ecosystem recovery and to improve the program's cost effectiveness, in 2007 the central government decided to extend the subsidy for another eight years but to reduce the cash compensation for lost grain yields to half of the previous levels (Yin and Yin, 2010).

The SLCP's indirect impact on household income is captured mostly in the earnings from adjusting the production and employment structures induced by the SLCP (Lin and Yao, 2014; Yin, 2009). Indeed, households participating in the SLCP have experienced substantial transformations in these respects. While cropland area has decreased sharply, farming on remaining cropland has become more intensive and animal husbandry switched from open grazing to pen-raising (Yao et al., 2010; Liu et al., 2013). At the same time, the SLCP has enabled the rural labor force freed from farming to seek and obtain off-farm jobs in and outside of their locales and the non-farming income generated has become a very large component of the household total income (Yin et al., 2014; Lin and Yao, 2014; Xu et al., 2006).

One question of common interest is to what extent the substantial household income gain has been driven by implementing the SLCP and whether this effect has to do with the heterogeneity of cropland retirement intensity and the status of household earnings (Zhao et al., 2015). In fact, a large body of literature has focused on answering this question. For example, Uchida et al. (2005) find that the average household net income increased considerably for the SLCP participants in Ningxia and Guizhou. Similarly, Liu and Zhang (2006) detect a positive impact of converting farmland to forests on household income in the proximity of Beijing and Tianjin. The evidence generated by Yao et al. (2010), and Li et al. (2011) also confirms a positive income effect, a larger part of which has indeed come indirectly from the structural adjustment and labor transfer into off-farm sectors.

More notably, Groom and Palmer (2012), using quantile regressions and pooled data from Ningxia and Guizhou, report that the SLCP's impact on household income was significantly positive at the lower quantiles of the income distribution, compared to their non-participating counterparts. The use of quantile regressions to assess the potentially differentiated income impacts is a novel step, but the data these authors used cover a short period of time (only 1998 and 2004). So, their study was unable to examine the more recent situation, particularly after 2008 when the subsidy was cut back substantially. Moreover, they did not consider the possible effects of such factors as on- and off-farm work times, on household income.

In contrast, Xu et al. (2004a) show that the growth rates in average income varied across regions over the period of 1999–2003, but the overall impact of the SLCP on participants' income was insignificant. Uchida et al. (2007) identify only a moderate success of the SLCP in achieving poverty alleviation; further, they fail to obtain evidence to support the claim that participating households have shifted more of their work time into off-farm wage-earning or self-employing activities. Wang and Maclaren (2012) even go so far as to assert that 58% of the families participating in the program considered themselves worse off after getting enrolled; also, farmers in the Wolong Nature Reserve intended to reconvert 22.6% of the land enrolled in the SLCP to farming after the end of the subsidies, and the land to be reconverted in northern Shaanxi could amount to 37.2% of the enrolled total.

Different, and often contradictory, conclusions have been drawn on household poverty reduction and income growth in previous studies. Why is this? First, most of the studies have focused on the income impact of the entire sample, without looking into the potentially differentiated impacts corresponding to the variable levels of SLCP enrollment (Zhao et al., 2015). Second, the datasets used in many studies have short-time coverages, either before 2006 (Xu et al., 2004a; Uchida et al., 2005; Groom and Palmer, 2012; Liu and Zhang, 2006), or only after 2006 (Yao et al., 2010; Wang and Maclaren, 2012), which may be inadequate to capture changes in the SLCP's income effects over time. Moreover, the program's effect and effectiveness are ultimately predicated on the internal and external local conditions under which it has been executed (Yin et al., 2010). Therefore, it is crucial to identify these conditions and incorporate them into an impact assessment.

In this article, we attempt to overcome the limitations of the previous studies of the SLCP's impact on poverty alleviation and income growth. We will do so, first, by using household survey data that cover a long period (1998–2011) and at the same time adopting alternative estimation strategies to reflect the subsidy regime shift. Second, we will classify the sample households into multiple groups according to their land areas enrolled and earnings to capture the potentially differentiated income effects of participating in the program, with particular attention given to those poor families. It is expected that based on appropriate quantile regressions (Meyer and Sullivan, 2013; Zhang et al., 2005), these steps will generate a rich set of empirical results and thus make a timely contribution to better understanding of the program's effect and effectiveness. Further, we hope that our work will shed light on how to properly assess similar ecological restoration efforts in other parts of the world.

The remainder of this paper is organized as follows: the next two sections describe the study site and survey data, following which the empirical model and estimated results are then presented, and closing remarks are made in the final section.

2. Study site

Our data for evaluating the income change induced by implementing the SLCP came from multiple rounds of household surveys conducted in the county of Wuqi in northern Shaanxi province (Fig. 1). Before discussing our surveys and presenting our data, it is worthwhile to provide a brief description of the county and the structural change of farmer's income there since the end of the last century.

Situated in the northwest of Yan'an municipality, Wuqi had a total population of 127,369 in 2011. While the official demographic statistics show that the county's rural residents remained close to 110,000, more than a half of the rural labor had been involved in off-farm and/or off-village employment and business activities (Wuqi Statistics Bureau, 2012). Before 1998, Wuqi had a cultivated land base of 123,700 ha, and a majority of the rural households also raised goats, whose population peaked to 280,000 in the late 1990s. As a consequence of extensive farming and open grazing, the county's land and vegetation were heavily degraded, making the problems of water runoff, soil erosion, and flash flooding extremely severe.

In response, the county began retiring croplands on steep slopes and converting them to forest and/or grass covers in 1998. Taking advantage of the national initiative, the county's set-aside of marginal cropland expanded tremendously in 1999—two years ahead of most other places across the country. Quickly, cropland was cut back to only 10,730 ha, and open grazing was completely banned (Wuqi SLCP Office, 2012). To facilitate the ecological and economic transformation, the county government has invested heavily in such activities as improving the quality of the remaining farmland, introducing new breeds of crops and animals, and promoting best land-use practices, complementing the national ecological restoration initiative. As such, Wuqi was later selected by the provincial and central governments as a model county in pioneering cropland retirement and restoration (Yao et al., 2010). It was based on these developments that our research team decided to monitor the program implementation and its impacts there since 2005.

Table 1 summarizes farmer's per-capita incomes from different sources from 1998 to 2011.[2] It can be seen that total income witnessed a remarkable increase over the period—from 1432 yuan in 1998 to 1968 yuan in 2004 and 3794 yuan in 2011. Farming income decreased from 947 yuan in 1998 to 482 yuan in 2006 and then rebounded to 695 yuan in 2011. Similarly, animal husbandry income decreased from 396 yuan in 1998 to 110 yuan in 2004 and slightly recovered to 180 yuan in 2011. Starting at 481 yuan in 1999, income from the SLCP subsidies rose to 883 yuan in 2004 and declined to 643 yuan on average in 2011. Meanwhile, the government began to subsidize farming in 2004 as well (at a level of only 16 yuan per capita), which rose to 213 yuan

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[2] The use of per-capita based figures helps avoid the cofounding effect of household size variation over time.

Fig. 1. Location of the study site.

in 2011. In comparison, off-farm income rose from merely 89 yuan in 1998 to 428 yuan in 2004 and then to 1783 yuan by 2011.

In sum, farming was the dominant source of income to all of the households in 1998 before they joined the SLCP, which, along with the strong economic growth, triggered the transformation of agriculture, the adjustment of local economy, and the transfer of labor into off-farm sectors. As a result, off-farm work has become the major source of family revenues. Despite the sharp reduction of income from crop and livestock production, the gains in off-farming income and program subsidies have much more than offset the income losses from crop and livestock production.

Table 1
Farmers' per capita income from different sources in Wuqi (1998–2011) (unit: yuan).

	Farming	Farming subsidy	Animal husbandry	SLCP subsidy	Off-farm	Total
1998	947	0	396	0	89	1432
1999	603	0	116	481	114	1314
2000	595	0	98	541	162	1396
2001	572	0	87	567	203	1429
2002	560	0	86	635	273	1554
2003	525	0	96	734	333	1688
2004	531	16	110	883	428	1968
2005	520	16	104	941	876	2457
2006	482	72	198	1031	858	2641
2007	696	105	114	707	936	2658
2008	652	174	141	769	1703	3619
2009	676	184	189	644	1736	3729
2010	717	182	186	645	1764	3894
2011	695	213	180	643	1763	3794

Notes:

1. The income figures, coming from the Wuqi Statistics Bureau (1998–2011), were deflated using the county's consumer price index based on 1990; using per-capita statistics is intended to avoid the confounding effect of variation of family size over time.

2. Farming income is income from producing corn, potatoes, and other minor crops; animal husbandry income is income from raising livestock; off-farm income is income from off-farm employment, mainly construction and services in local towns as well as large cities. Total income is the gross income from all sources. As a result of the existence of another minor category of income from other sources, these items do not add up to the total.

3. Household data

Our research team carried out repetitive surveys of 200 randomly chosen households in Wuqi in 2005, 2007, and 2012. In our first survey in 2005, we asked the sample households to provide the relevant information for 2004 and 1998, based on a detailed questionnaire that we had designed following focus group interviews and pre-tests. Because of the late initiation of our survey, however, we were concerned that recalling what had happened in 1998, which was several years earlier, might not give rise to information as accurate and reliable as that for the immediately past year (2004). But later we discovered that family incomes were generally low and did not vary much before the SLCP was initiated.[3] Subsequent visits to the selected households in 2007 and 2012 generated data for 2006 and 2011, respectively. Notably, 1998 is the last year before the SLCP was formally launched in Wuqi; 2004 is the year when the program enrollments almost peaked and thus did not gain much thereafter; 2006 is the year when the original eight-year program duration expired there and the government decided to continue subsidizing farmers for another eight years, but at reduced levels; and 2011 is the year of our last survey.

Because some of the sample households migrated to other places after 2005 or failed to provide certain family information in the subsequent surveys upon close cross-checks, we derived an effective sample of 182 households throughout the period of 1998–2011. In addition to cropland retirement and demographic features, our questionnaire included production activities (farming, forestry, and other) and the corresponding labor times, the distance to the nearest town, and the destinations of off-farm work—outside of the province, outside of the county but inside the province, and inside the county. In addition, we gathered essential statistics of local economic conditions to supplement our analysis. All the nominal monetary indicators were deflated with the county's Producer Price Index or Consumer Price Index, respectively, with 1998 as the base year. To our knowledge, this is one of the few comprehensive and up-to-date survey-based panel datasets

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[3] See Table 1 and our survey data summary below for more detail.

Table 2
Basic features of the surveyed households in Wuqi.

	1998	2004	2006	2011
Area enrolled in the SLCP (ha)	0.00	2.57	2.74	2.74
	(0.00)	(1.56)	(1.87)	(1.30)
Age of household head (year)	44.48	47.84	49.57	55.89
	(10.42)	(10.42)	(10.85)	(11.53)
Household head education	4.51	5.51	5.57	5.92
(year)	(2.32)	(3.87)	(3.95)	(3.57)
Family size (person)	5.12	4.79	4.59	3.96
	(1.56)	(1.56)	(1.99)	(1.28)
Number of laborers	4.32	3.4	2.87	2.45
	(1.34)	(1.35)	(1.37)	(1.06)
Cultivated land (ha)	3.39	0.81	0.72	0.76
	(1.70)	(0.35)	(0.43)	(0.49)
Farming expenditure (yuan)	1900.3	1156.8	1144.69	1023.73
	(1078)	(1271)	(3979)	(2232)
Farming time (day)	486.26	191.36	123.97	118.56
	(2116.1)	(159.77)	(59.31)	(47.67)
Off-farm work time (day)	10.46	182.43	222.7	231.8
	(41.21)	(123.24)	(144.16)	(173.48)
Destinations of off-farm work	0.86	1.43	1.36	1.09
	(0.57)	(1.05)	(1.40)	(1.47)

Notes:
1. 1998 is the last year before the Sloping Land Conversion Program (SLCP) was initiated, 2004 is the year when the SLCP enrollment was virtually completed, 2006 is the year when the original eight-year duration of the subsidy expired, and 2011 is the year of our last survey.
2. Figures in parentheses are standard deviations.
3. Working ages range from 18 to 65.
4. Destinations for off-farm employment are defined as follows: 1 if inside the county, 2 if outside of the county but inside the province, and 3 if outside of the province.
5. All the values are in real terms, deflated by the county's Consumer Price Index (with 1998 as the base year).

regarding the SLCP implementation and economic impact, in spite of its limited spatial scope.

The basic production and employment dynamics and demographic features of the surveyed households are listed in Table 2. It can be seen that they had virtually completed their cropland enrollment into the SLCP by 2004—with an average amount of 2.57 ha per household, which later stabilized at 2.74 ha. However, the areas of individual enrollments varied a great deal—the lowest being 0.66 ha and the highest being 12 ha per household. Meanwhile, the average amount of cultivated land decreased from 3.39 ha per household in 1998 to 0.81 ha in 2004, and it later expanded slightly due to terracing and/or leveling efforts. Accordingly, farming became more intensive. The expenditure on commercial inputs (such as fertilizers, improved seeds, and crop cover sheets) increased from 560.6 yuan per ha in 1998 to 1428.2 yuan in 2004; the average farming time increased from 143.4 days per ha in 1998 to 236.3 days in 2004. After 2004, however, the per ha cash expenses and labor time in farming declined a bit because of an increasing amount of labor having already moved into off-farm sectors and relatively low returns to farming activities (Yin et al., 2014). In the meantime, off-farm work time increased from 10.5 days per family in 1998 to 231.8 days in 2011.

Table 3 further reveals the potential linkages between varied areas enrolled in the SLCP (in 2006) and per-capita subsidy/income by dividing the whole sample into three groups according to the extent of per-household enrollment—those having less than 1.3 ha enrolled (29.6%), those having an enrollment of 1.3–2.0 ha (26.4%), and those having more than 2.0 ha enrolled (44.0%). For the group with an enrolled area below 1.3 ha, the SLCP subsidy accounted for 36.3% of the per capita income in 2004, which declined to 25.5% in 2006 and 10.9% in 2011. For the group with an enrollment of 1.3–2.0 ha the proportion of the program subsidy in total income was 49.9% in 2004 and dropped to 35.4% in 2006 and 15.9% in 2011. For the group with an enrollment of above 2.0 ha, the program subsidy amounted for 61.8% of total income in 2004, 46.4% in 2006, and 27.2% in 2011.

Table 3
Income composition and changes over time for groups with different levels of cropland retirement (unit: yuan/per capita).

Year	Enrolled land (ha)	SLCP subsidy	Farming	Animal husbandry	Off-farm work	Total
1998	<1.3	0	781.5	388.9	82.0	1252.5
	1.3–2.0	0	965.7	338.0	84.2	1388.0
	>2.0	0	1232.2	403.3	94.0	1729.5
2004	<1.3	563.1	451.5	132.5	402.5	1549.7
	1.3–2.0	831.3	389.9	106.4	440.2	1767.7
	>2.0	1715.2	742.2	119.6	658.9	3235.9
2006	<1.3	567.3	898.0	181.1	675.4	2321.8
	1.3–2.0	835.0	672.5	159.9	794.6	2461.9
	>2.0	1707.8	392.7	256.4	1125.5	3482.4
2011	<1.3	386.1	986.8	100.8	1352.0	2825.8
	1.3–2.0	503.5	932.9	129.2	1663.5	3229.2
	>2.0	1157.7	536.1	343.0	2676.1	4712.8

Notes:
1. Dividing retired cropland into the three different levels is based on its distribution in the sample, the purpose of which is to show the different economic dynamics associated with the different levels.
2. Farming income is income from producing corn, potatoes, and other minor crops; animal husbandry income is income from raising livestock; off-farm income is income from off-farm employment, mainly construction and services in local towns as well as large cities. For convenience, farming subsidies are included in farming income here. Total income is the gross income from all sources.
3. The income figures were deflated using the county's producer price index based on 1998.

Similarly, for the group with an enrolled area less than 1.3 ha, farming income declined from 781.5 yuan per capita in 1998 to 451.5 yuan in 2004, and rebounded to 1186.8 yuan in 2011. In other words, the proportion of farming income (including subsidies since 2006) in total income was 72.2% in 1998 but dropped to only 29.1% in 2004 and then increased to 45.3% in 2011. For the group of enrolled land in the range of 1.3–2.0 ha, farming income decreased from 965.7 yuan per capita in 1998 to 389.9 yuan in 2004, and finally rose to 932.9 yuan in 2011. Put differently, the proportion of farming income to total income was 62.4% in 1998, but declined to 23.4% in 2004 and then rose to 29.4% in 2011. For the group with an enrolled area above 2.0 ha, farming income decreased from 1332.2 yuan per capita in 1998 to 536.1 yuan in 2011 and, accordingly, the proportion of farming income to total income declined from 73.2% in 1998 to 12.6% in 2011.

In contrast, for the group with an enrolled area below 1.3 ha, off-farm income increased from 82.0 yuan per capita in 1998 to 1352.0 yuan in 2011, leading the proportion of off-farming income to total income to increase from 6.6% in 1998 to 46.2% in 2011. Likewise, for the group with an enrolled area in the range of 1.3–2.0 ha, off-farm income increased from 84.2 yuan per capita in 1998 to 1663.5 yuan in 2011 (namely, from 6.1% to 51.5%). For the group with an enrolled area above 2.0 ha, off-farm income rose from 94.0 yuan per capita in 1998 to 2676.1 yuan in 2011 (or from 5.4% to 56.8%).

In short, we have observed that the more cropland was retired, the greater amount of subsidy was received and the more rural labor was set free from farming; and as a result of these changes, large reduction in farming income and even larger gain in off-farm income occurred. However, these effects are mediated by the statuses of household earnings and external factors including the local economic conditions. Meanwhile, the household income gap enlarged. For instance, family income for the group with the largest enrollment (>2 ha) was 38.1% higher than that of the group with the smallest enrollment (<1.3 ha) in 1998, but that gap swelled to 61.1% in 2011. Fig. 2 presents the distribution of per capital income and its shift over time.

Therefore, it is essential to divide the whole sample into separate income quantiles in identifying the differentiated effects of the major determinants. Of course, this is more appropriate analytically; but more importantly, it will enable us to clearly identify the program's effect on poverty alleviation and livelihood improvement (Groom and Palmer, 2012).
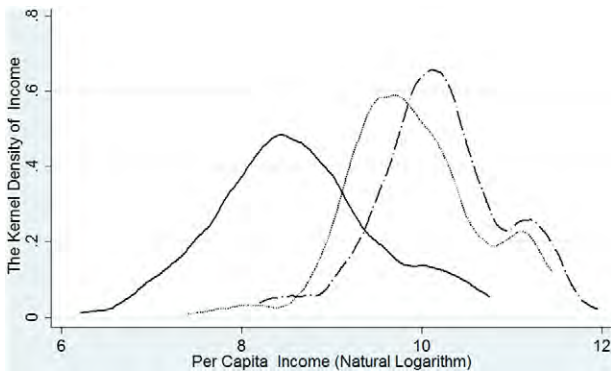
Fig. 2. Distribution of farmers' per capita income and its shift over time.

4. Empirical model

Unlike other studies, though, all of our sample households have participated in the SLCP, albeit with different levels of enrollment. The universal participation means that no control group is available for identifying the impact of program participation using a conventional treatment effect model, such as the difference in differences one (Uchida et al., 2007; Yao et al., 2010). Nonetheless, we argue that it is still possible to conduct a meaningful analysis of the impact if our data contain sufficient variation in terms of the extent of participation and income distribution (Furno, 2013), as we have shown. In other words, what we intend to pursue is to assess the differentiated income effects induced by the varied levels of program participation and the change subsidies.

Here, we follow the strategy adopted by Finkelstein (2007) in measuring the effect of health insurance. Because the introduction of Medicare in the U.S. affected the whole nation, empirical researchers have found it difficult to construct a counterfactual that can be used to understand how the presence of Medicare has affected the healthcare marketplace. The author devised an insightful strategy to circumvent this difficulty by comparing the effect of the introduction of Medicare on hospital expenditures by elderly households in different regions of the country (Finkelstein, 2007). Her rationale is that prior to introducing Medicare, the incidence of hospitalization insurance policies varied widely across regions, so the fraction of elderly households who experienced changes in their ability to pay for hospital-based care when Medicare was introduced also varied across regions. That is, even though the policy change was national, the effect of that policy relative to the prior situation varied substantially across regions.

As far as our case is concerned, we have already shown that the income statuses and the extents of program enrollment varied across households. Our earlier description has also made it clear that the more cultivated land is enrolled into the SLCP, the greater is the amount of time that household members spent in off-farm jobs, which in turn enhances family income in a major way. Moreover, these effects also vary across different levels of household earnings. Therefore, it appears that this is a case well suited for quantile regression (QR) (Furno, 2013), which allows us to analyze not only the median but also the lower and the upper quantiles (Koenker and Bassett, 1978).

Consistent with previous studies (Uchida et al., 2007; Liu et al., 2010; Groom and Palmer, 2012) and our discussion above, we posit that the income of a household is a function of its participation in the SLCP as well as a set of well-identified covariates, including inputs used in farming and non-farming activities, total availability of family workforce, and local economic condition, among other factors. More specifically, our basic linear conditional quantile function is defined as:

$$Y(\tau|x) = \alpha + \beta_i X_i + \gamma_j T_j + \delta_j X_1 T_j + \mu \text{ for } i = 1, 2, 3 \ldots, 12; j = 1, 2, 3$$

where Y is the natural logarithm of household income; X_1–X_5 (all in natural logarithm) are, respectively, household's land enrolled in the SLCP, cultivated land area, farming expenditure, farming time, and off-farm work time; X_6–X_{10} are the ratio of off-farm to total labor time, the destination dummy of off-farm work (1 if inside the county, 2 if outside of the county but inside the province, and 3 if outside of the province), the number of family laborers, township-level per capita GDP (in natural logarithm), and the ratio of retired cropland to total cropland area in 1998 for each township; X_{11} is the ratio of farming subsidies to total income; X_{12} is the product of the ratio of off-farm to total labor time (X_6) and the ratio of retired cropland to total cropland area in 1998 (X_{10}); T is a set of time dummy variables ($T_1 = 1$ for 2004, 0 otherwise; $T_2 = 1$ for 2006, 0 otherwise; $T_3 = 1$ for 2011, 0 otherwise); $\alpha, \beta_i, \gamma_j$, and δ_j are the parameters to be estimated; and u is the error term.

We argue that using the actual amount of cropland enrolled in the SLCP (X_1) is more appropriate for capturing the effect of its contribution to household income. Likewise, we include township-level per capita GDP (X_9) to reflect the potential effect of the local economic condition on a household's income to avoid overestimating the program impact, the ratio of retired cropland to total cropland area in 1998 for each township (X_{10}) to capture the variability of each township's cropland available for participating in the program, the ratio of farming subsidies to total income (X_{11}) as another contributor to income growth, and the product (X_{12}) of the ratio of off-farm to total labor (X_6) and the ratio of retired cropland to total cropland area in 1998 (X_{10}) to capture their possible interactive effect on family income. The aim of incorporating dummy variables T_1, T_2, and T_3 is to capture the trend effect, if any, associated with external changes of the economic condition over time (Wooldridge, 2002; Yin, 2009). We also include the interactive terms (X_1, T_t) of a household's subsidy from participating in the SLCP (X_1) and the time dummy variables T_j to detect whether changed subsidy regime has actually caused a different effect of the program subsidy on household income over time. For our analytic purpose, the four chosen quantiles are $\tau \in \{0.25, 0.5, 0.75, 0.90\}$.

The above model will be estimated with data for the whole period of 1998–2011 under the four quantiles as well as the lumped-up case for comparison. Alternatively, to explicitly determine the impact of the subsidy regime shift after 2007 on household income as well as to reflect the further improved economic conditions, we will also explore a different strategy of estimation by running separate regressions for the two sub-periods—1998–2004 and 2006–2011. Further, given the nature of our sample data—repetitive surveys over a long period, we maintain that fixed-effect estimation would be more appropriate, compared to the random-effect counterpart that assumes either little variation or similar change in the control variables over time.

Lastly, it is necessary to assume no selection bias in household's participation to obtain consistent estimates (Xu et al., 2004b; Yin et al., 2010). Because the SLCP is a government-sponsored program, a household's participation was, by and large, not based on its own selection. Indeed, our interviews indicated that households had little choice regarding the specific tracts or sizes of farmland to be converted or the trees to be planted. Thus, we will take the argument made by Xu et al. (2004b) and Uchida et al. (2005), who claimed that farmers' self-selection in SLCP participation could be ignored. In fact, this argument has been recently validated by Yin et al. (2014), whose statistical testing rejected the hypothesis that there exists farmers' self-selection in SLCP participation.

5. Estimated results

In general, the goodness of fit of the different versions of our empirical model is quite reasonable, while regressions for the whole period feature slightly higher R^2 values. Further, the outcome of the fixed-effects estimation indeed outperforms that of the random-effect counterpart in terms of the goodness of fit and the significance of coefficients. Our results unequivocally demonstrate the relevance and power of

Table 4
Regression results for the period of 1998–2011.

Independent variables	Lumped data	Quantiles			
		0.25	0.50	0.75	0.90
X_1	0.14 (1.89)*	0.25 (3.15)***	0.20 (2.02)**	0.13 (1.71)	0.09 (1. 32)
X_2	0.01 (1.32)	0.03 (1.93)**	0.01 (1. 23)	0.00 (0.57)	−0.03 (1. 12)
X_3	0.31 (4. 21)***	0.52 (5. 48)***	0.27 (4.32)***	0.10 (7.87)***	0.07 (2. 14)**
X_4	0.03 (1.52)	0.07 (2.53)**	0.05 (1.76)*	0.02 (1.58)	−0.07 (1.28)
X_5	0.54 (2.45)***	0.39 (2.12)**	0.45 (3.34)***	0.65 (3.15)***	0.94 (6.12)***
X_6	0.18 (3.16)***	0.10 (1. 82)*	0.11 (2.01)**	0.21 (3.54)***	0.28 (2.43)***
X_7	0.12 (3.11)***	0.07 (1.67)*	0.11 (2.18)**	0.15 (2.45)**	0.19 (4. 44)***
X_8	0.13 (2.53)**	0.11 (1.11)	0.11 (1.69)*	0.10 (2.34)**	0.14 (4.24)***
X_9	0.23 (2.33)**	0.44 (3. 65)***	0.40 (3.73)***	0.18 (2.18)**	0.11 (1.83)*
X_{10}	0.78 (5.31)***	0.44 (1.85)*	0.57 (2.43)**	0.70 (6.48)***	0.88 (7. 88)***
X_{11}	0.03 (1.31)	0.05 (2.05)**	0.03 (1.81) *	0.01 (1.51)	0.00 (1. 23)
X_{12} ($X_6 \times X_{10}$)	0.53 (2. 41)**	0.41 (1.76)*	0.48 (2.54)**	0.57 (7. 81)***	0.69 (5.31)***
T_1	0.28 (2.24) **	0.18 (1.73)*	0.26 (2.14) **	0.31 (3.61)***	0.43 (2.87)***
T_2	0.39 (5.51) ***	0.23 (3.11)***	0.32 (3.94)***	0.41 (5.98)***	0.51 (6.28)***
T_3	0.22 (2.08) **	0.15 (2.11)**	0.26 (2.15)**	0.41 (3.09)***	0.32 (1.81)*
$T_1 \times X_1$	0.13 (2.32)**	0.10 (1.78)*	0.12 (2.05)**	0.16 (3.19)***	0.18 (6.23)***
$T_2 \times X_1$	0.17 (3.15)***	0.13 (2. 23)**	0.15 (2.87)***	0.21 (4.84)***	0.24 (3.43)***
$T_3 \times X_1$	0.08 (2.02)**	0.11 (3. 39)***	0.10 (2.18)**	0.07 (1. 75)*	0.05 (1.81)*
Adjusted R^2	0.62	0.59	0.61	0.63	0.60

Notes:
1. Y is household income (in natural logarithm); X_1, X_2, X_3, X_4 and X_5 (all in natural logarithm) are household's subsidy of the SLCP, area of cultivated land, farming expenditure, farming time, and off-farm work time; X_6 is the ratio of off-farm labor to total labor, X_7 the destination of off-farm work (1 if it is inside the county, 2 outside of the county but inside the province, and 3 outside of the province), X_8 the number of family laborers, X_9 township's per capita GDP (in natural logarithm), X_{10} the ratio of retired cropland to total cropland area in 1998 for each township, X_{11} the ratio of farming subsidy to total income, and X_{12} the product of X_6 and X_{10}; T is a set of time dummy variables ($T_1 = 1$ for 2004, 0 otherwise; $T_2 = 1$ for 2006, 0 otherwise; $T_3 = 1$ for 2011, 0 otherwise).
2. The total observations used were 728.
3. Figures in parentheses are t statistics; *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

quantile-based regressions, instead of those using lumped-up data. Table 4 shows that during the whole period, the amount of cropland enrolled in the SLCP has had a positive income impact of 14%, which is modestly significant, if the data are lumped up in a single regression. In contrast, based on separate regressions, the amount of cropland enrolled in the SLCP has made a much larger contribution to the income of those households in the lower quantiles at greater significance level—29% for the 0.25th quantile and 21% for the 0.50th quantile. But the same effect becomes no longer significant for households in the other two upper income quantiles.

Differences are also revealed in the coefficients of many other variables and the levels of their significance in the QRs. Thus, we will no longer relate them to those of the regressions based on lumped data heretofore in reporting our findings. It can be seen that farming expenditure, off-farm work time, the ratio of off-farm labor to total labor, the destination of off-farm work, local per-capita GDP, and the ratio of retired to total cropland area in 1998 are all positive at certain levels of significance. On the other hand, area of cultivated land has a tiny positive income effect only on families in the 0.25th income quantile at the 95% significance level. Similarly, the coefficients of farming time and subsidy are somewhat significant for households in the 0.25th and 0.50th income quantiles, but it is insignificant for households in the 0.75th and 0.90th income quantiles. The small, positive coefficient of the number of family laborers is only significant in the two upper quantiles. The coefficient of the interactive term between the ratio of off-farm labor to total labor and the ratio of retired cropland in a given year to total cropland prior to the program is significantly positive, and its magnitude is larger for households in the higher quantiles.

Moreover, the coefficients of the three time dummy variables are positive at various levels of significance, suggesting a persistent trend effect. Again, the higher the income quantile, the stronger the effect is. The coefficients of the interactive terms of a household's subsidy from participating in the SLCP and the time dummies further indicate that for a given quantile, the effect of program subsidy peaked in 2006 and the reduced subsidy thereafter had a diminished effect on household income. Prior to the subsidy regime shift, though, the higher the quantile, the more pronounced the interactive effect was.

Tables 5 and 6 list the estimated results for the two sub-periods—1998–2004 and 2006–2011. Notably, the estimated income impacts of the SLCP, as well as several other variables, are quite different from those derived from the QRs based on data for the whole period. First, the SLCP subsidy policy in the earlier period has a much greater effect on income of all households than that in the later period. Second, the coefficient is significant in all quantiles in the earlier period, while it remains so only in the 0.25th and 0.50th income quantiles later. Additionally, the area of cultivated land has a significantly positive effect on the income of households in the 0.25th and 0.50th quantiles in the earlier period, but it is no longer significant at all in the later period. Farming expenditure has a positive effect on the income of all households in the two sub-periods; and, again, its effect is diminished during the later sub-period. Also, the lower the quantile, the larger the magnitude of the coefficient is. Farming time has a positive, albeit small, income effect on households in the 0.25th and 0.50th quantiles at the 95% significance level during 1998–2004; later, it maintains a tiny positive effect only on the lowest quantile. For households in the two upper quantiles (0.75th and 0.90th), that variable has an insignificant effect during both sub-periods. The coefficient of farming subsidies is significant only to households in the lowest quantile in the first sub-period, but it is so to households in the two lower quantiles in the second sub-period with enhanced magnitudes.

Off-farm work time has a significant positive effect on the income of all households in the two sub-periods, and that effect is generally larger in the second sub-period than in the first. The coefficient is significant at the 99% level for the 0.75th and 0.90th quantiles and at lower significance levels for the 0.25th and 0.50th quantiles. Likewise, the proportion of off-farm labor in total labor has a significantly positive effect on household income in all quantiles in the two sub-periods; the effect is generally larger in the second sub-period than in the first, and the higher the income quantile the larger the effect. The off-farm destination dummy has a small, positive effect on households in all but the lowest income quantiles during the two sub-periods. The number of family laborers has a significantly positive effect across the quantiles during 1998–2004, while its effect is somehow significant only on households in the two upper quantiles later.

Table 5
Regression results for the period of 1998–2004.

Independent variables	Lumped data	Quantiles			
		0.25	0.50	0.75	0.90
X_1	0.25 (4. 28)***	0.33 (3. 64)***	0.18 (3.32)***	0.20 (4.33)***	0.40 (9.23)***
X_2	0.01 (2.01)*	0.02 (2.12)**	0.03 (2.43)**	0.02 (1.31)	0.00 (1.29)
X_3	0.38 (7.92)***	0.63 (5. 52)***	0.32 (5.31)***	0.23 (6.15)***	0.11 (4.18)***
X_4	0.09 (1.81)*	0.16 (2.21)**	0.11 (2.09)**	0.07 (1.43)	0.03 (1.37)
X_5	0.54 (2. 12)**	0.34 (1.75)*	0.38 (2. 26)**	0.62 (3.32)***	1.03 (4.62)***
X_6	0.95 (2. 18)**	0.61 (1.98)*	0.77 (2.31)**	1.03 (7.72)***	1. 27 (5.61)***
X_7	0.19 (1. 82)*	0.14 (1.35)	0.17 (1.78)*	0.20 (2.37)**	0.32 (2.36)**
X_8	0.04 (9.21)***	0.08 (5.43)***	0.05 (3. 40)***	0.03 (4.22)***	0.01 (4.73)***
X_9	1.74 (6.87)***	0.95 (6.23)***	1.00 (4.44)***	2.04 (5.76)***	2.65 (3.69)***
X_{10}	0.78 (6. 66)***	0.65 (3.43)**	0.74 (7.76)***	0.83 (4.13)***	1.74 (6.08)***
X_{11}	0.01 (1.53)	0.03 (1.95)*	0.02 (1.57)	0.00 (1.52)	0.00 (1. 39)
X_{12} ($X_6 \times X_{10}$)	0.77 (6.23)***	0.28 (1.69)*	0.41 (2.22)**	0.82 (7.32)***	1.12 (4.65)***
T	0.35 (2.41) **	0.33 (1.82)*	0.28 (2.43) **	0.39 (3.57)***	0.48 (2.72) ***
$T \times X_1$	0.22 (2.41)**	0.12 (1.93)*	0.18 (2.39)**	0.37 (4.72)***	0.47 (6.77)***
Adjusted R^2	0.56	0.54	0.59	0.53	0.55

Notes:
1. Y is household income (in natural logarithm); X_1, X_2, X_3, X_4 and X_5 (all in natural logarithm) are household's subsidy of the SLCP, area of cultivated land, farming expenditure, farming time, and off-farm work time; X_6 is the ratio of off-farm labor to total labor, X_7 the destination of off-farm work (1 if it is inside the county, 2 outside of the county but inside the province, and 3 outside of the province), X_8 the number of family laborers, X_9 township's per capita GDP (in natural logarithm), X_{10} the ratio of retired cropland to total cropland area in 1998 for each township, X_{11} the ratio of farming subsidy to total income, and X_{12} the product of X_6 and X_{10}; T is a time dummy (1 for 2004, 0 otherwise).
2. The total observations used in the regressions were 364.
3. Figures in parentheses are t statistics; *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

The per-capita GDP and the ratio of retired cropland to total cropland area in 1998 in each township have a strong, positive effect on household income in all quantiles in the two sub-periods. Furthermore, the effects of these two variables become even larger in the second sub-period than in the first, and they are generally larger for households in the higher quantiles. Similarly, the interaction between the ratio of off-farm to total labor and the ratio of retired cropland to total cropland area in 1998 is significant in all cases, but its effect tends to be more pronounced in the upper quantiles and during the later sub-period. The trend effect is positive at various levels of significance, and the coefficients of the upper quantiles are much larger. The coefficient of the interactive term between the program subsidy and the time dummy, again, shows that the reduced subsidy diminished its effect on household income; prior to the subsidy regime shift, however, the interactive effect was more prominent in the higher quantiles.

6. Discussion and conclusions

We set out to test the hypothesis that household income in places where the SLCP is implemented is determined by different areas enrolled in the program, local natural and economic conditions, and household standings in different income quantiles, among other factors. As a key part of this endeavor, we decided to address the question of whether or not the rural poor have benefitted more than proportionately from their participation in the program. To that end, we have estimated an empirical model with alternative strategies and data collected from 182 households in Wuqi of the Loess Plateau region, covering the period of 1998–2011. Our results have confirmed the logic of our conceptual reasoning for running QRs, the plausibility of our model identification, and the appropriateness of our estimation strategies. Because the dependent variable and many of the independent variables of our

Table 6
Regression results for the period of 2006–2011.

Independent variables	Lumped data	Quantiles			
		0.25	0.50	0.75	0.90
X_1	0.14 (2.07)**	0.19 (4.28)***	0.15 (8.24)***	0.12 (1.39)	0.09 (1.54)
X_2	0.00 (0.99)	0.01 (0.76)	0.00 (0.63)	−0.01 (0.79)	−0.03 (0.96)
X_3	0.27 (4.78)***	0.52 (6.43)***	0.37 (6.32)***	0.07 (4.76)***	0.03 (3.76)***
X_4	0.03 (1.34)	0.08 (1.72)*	0.04 (0.46)	0.00 (0.94)	−0.01 (0.83)
X_5	0.67 (2.21)**	0.48 (1.83)*	0.59 (2.37)**	0.99 (6.11)***	1.27 (6.82)***
X_6	1.42 (2.27)**	1.21 (1.75)*	1.33 (2.18)**	1.38 (8.42)***	1.67 (8.85)***
X_7	0.12 (1.78)*	0.13 (0.20)	0.11 (1.81)*	0.13 (1.89)*	0.20 (2.14)**
X_8	0.13 (1.66)	0.18 (1.59)	0.10 (1.36)	0.11 (1.87)*	0.21 (2.41)**
X_9	1.90 (7.43)***	1.01 (6.02)***	1.50 (3.23)***	2.61 (5.45)***	3.48 (6.85)***
X_{10}	1.17 (5.76)***	0.78 (2.20)**	1.05 (7.51)***	1.29 (7.86)***	1.54 (8.31)***
X_{11}	0.05 (1.76)*	0.07 (3.17)***	0.06 (1.92) *	0.03 (1.63)	0.01 (1.54)
X_{12} ($X_6 \times X_{10}$)	0.93 (2.18)**	0.78 (1.73)*	0.87 (2.27)**	1.02 (5.28)***	1.17 (8.75)***
T	0.24 (2.32)**	0.10 (1.89)*	0.22 (2.27)**	0.28 (4.16)***	0.39 (4.23) ***
$T \times X_1$	0.04 (2.31)**	0.06 (3.14)***	0.04 (2.28)**	0.03 (1.84)*	0.04 (1.67)*
Adjusted R^2	0.51	0.55	0.50	0.57	0.55

Notes:
1. Y is household income (in natural logarithm); X_1, X_2, X_3, X_4 and X_5 (all in natural logarithm) are household's subsidy of the SLCP, area of cultivated land, farming expenditure, farming time, and off-farm work time; X_6 is the ratio of off-farm labor to total labor, X_7 the destination of off-farm work (1 if it is inside the county, 2 outside of the county but inside the province, and 3 outside of the province), X_8 the number of family laborers, X_9 township's per capita GDP (in natural logarithm), X_{10} the ratio of retired cropland to total cropland area in 1998 for each township, X_{11} the ratio of farming subsidy to total income, and X_{12} the product of X_6 and X_{10}; T is a time dummy (1 for 2011, 0 otherwise).
2. The total observations used in the regressions were 364.
3. Figures in parentheses are t statistics; *, **, and *** denote significance at 10%, 5%, and 1% levels, respectively.

model are transformed logarithmically, the corresponding coefficients can be interpreted as elasticities. Due to space limit, however, we will leave this task to interested readers.

First, we have demonstrated that farming income was the dominant source of income common to all of the households in 1998; thereafter, implementing the SLCP, coupled with rapid economic growth, triggered the transformation of agricultural production and the transfer of rural labor into off-farm sectors. Overall, the SLCP subsidy accounted for over 30% of per-capita total income in 2004 and at least 11% more recently. Given this variation as well as that across income quantiles, we argued that it is more sensible to run QRs separately for the two sub-periods (1998–2004 and 2006–2011). Our results show that the subsidy policy in the earlier period has a greater effect on income of all households than that in the later period, and the estimated coefficient of participating in the SLCP is significantly positive in all quantiles earlier but only so in the two lower income quantiles (0.25th and 0.50th) later. Consistent with what was reported by Groom and Palmer (2012) and Wang and Maclaren (2012), this suggests that the income impact of the SLCP on households in the higher-income quantiles lasted for a shorter duration, implying that the program has been largely successful in achieving its objectives of environmental restoration and poverty reduction.

In contrast, if we run the QRs based on data for the whole period (1998–2011), the estimated coefficient of SLCP enrollment is never significant to households in the two upper income quantiles, which seems less reasonable and convincing. Meanwhile, the coefficients of the interactive terms between program subsidy and time dummy variables indicate a large drop of the subsidy effect in 2011 following a peak in 2006. The finding that a larger area of cropland enrolled in the SLCP resulted in a greater direct impact of the SLCP on household income, especially during earlier sub-period (1998–2004), confirms what was previously reported by Liu and Zhang (2006) and Uchida et al. (2005). But this result differs from the conclusion drawn by Zhang et al. (2005) that the SLCP had a significantly positive income impact only on the poor farmers.

Also, our analysis has revealed that off-farm work time has a significantly positive effect on the income of all households in the two sub-periods, and the effect becomes even larger in the second sub-period. Likewise, the proportion of off-farm labor in total labor time has a significantly positive effect on household income in all quantiles in the two sub-periods, and the effect is larger in the second sub-period as well. In addition, the destination of off-farm work has a positive, albeit small, effect on households in all but the lowest income quantiles during the two sub-periods. Taken together, these results suggest that off-farm job and earning opportunities were more important to households in the higher income quantiles than to those in the lower ones; and their importance was strengthened during the later years of our sample coverage. Put differently, implementing the SLCP was aided tremendously by the plentiful job opportunities in the township and urban areas, allowing rural labor to find jobs and generate significant amount of off-farm income. Should this condition have not existed, the program would not have been so successful in transferring the large amount of displaced labor into non-farming sectors of the economy, resulting a lot of idled rural labor. Policymakers in other parts of the world should be cognizant of this situation if and when they are conceiving similar programs.

Our analysis has further found that the area of cultivated land has a positive effect on the income of all but households in the 0.75th and 0.90th quantiles during 1998–2004, whereas its coefficient becomes insignificant for households of all quantiles thereafter. This outcome is unsurprising, however, given the large reduction of cultivated land by 2004 and limited profitability of farming (Yin et al., 2013). Farming expenditure has a more positive income effect on all households during 1998–2004 than during later years. The effect of labor time spent on farming is significant for households early on in the 0.25th and 0.50th quantiles but only barely significant to households in the lowest

quantile later. In combination, these results indicate that farming was more important to households in the lower quantiles than to those in the higher quantiles in the early sub-period; but the importance of farming faded away later, along with the economic transformation (Yin and Zhao, 2012).

The local township-level per capita GDP and ratio of retired cropland to total cropland area in 1998 have significant positive effects on household income in all quantiles in the two sub-periods. Also, the effects of these two variables even become larger in the second sub-period than in the first. Additionally, the interaction between the ratio of off-farm to total labor and the ratio of retired cropland to total cropland area in 1998 is significant in all cases, but the income effect tends to be more prominent in the upper quantiles and during the later sub-period. These findings illustrate that a better-developed local economy and a greater extent of program participation are more beneficial to households, especially to those in higher income brackets (Yin et al., 2013).

Moreover, our analysis indicates that the local towns and county seat used to be the primary destinations of off-farm work. With the leveling off of local energy production in recent years, off-farm opportunities in Wuqi county have become more limited in absorbing the surplus labor from low-income households and continuing the transformation of the local economy (Yi et al., 2006; Liu and Zhang, 2006; Wang and Maclaren, 2012). Fortunately, government and business entities have made progress in exploring alternative employment options, such as expanding vegetable and fruit production and creating new and high-yield cropland by means of terracing and leveling, among other things (Yao et al., 2010).

Going forward, it is thus necessary for the government to target the subsidy toward low-income households, particularly those with larger amounts of cropland enrolled in the SLCP and/or less off-farm labor market participation to avoid any potential reconversion (Yin et al., 2014). Likewise, the local agencies should continue promoting economic development and exploring means, such as information service, credit provision, and technical training, to provide a better and more supportive external economic setting to sustain the restored ecosystems and income growth. At the same time, it is necessary for communities to intensify crop production on reduced cropland to absorb more surplus labor and further increase food productivity (Yao et al., 2010). In this regard, it's an important step to provide essential farming subsidies; however, they have so far been effective only to those households in the two lower income quantiles.

Finally, it is worth noting that because the data used in this study cover only one county, in which all of the households have participated in the SLCP, our findings of the income effects of program participation as well as other factors may not apply to other places, especially those with local situations different from that of Wuqi. To reach a broader conclusion, more data reflecting the local social-ecological conditions should thus be collected and a clear baseline established in the future. Of course, follow-up work ought to be pursued to examine what happens to the sample site of this study in the longer term.

Acknowledgments

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Case study

An improved solution of local window parameters setting for local singularity analysis based on Excel VBA batch processing technology

CrossMark

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ABSTRACT

In this paper Excel VBA is used for batch calculation in Local Singularity Analysis (LSA), which is for the information extracting from different kinds of geoscience data. Capabilities and advantages of a new module called Batch Tool for Local Singularity Index Mapping (BTLSIM) are: (1) batch production of series of local singularity maps with different settings of local window size, shape and orientation parameters; (2) local parameter optimization based on statistical tests; and (3) provision of extra output layers describing how spatial changes induced by parameter optimization are related to spatial structure of the original input layers.

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1. Introduction

Separating anomalies from background according to an assumed threshold is essential both in exploration geochemistry and environmental geochemistry. Geochemical anomalies have been used as one of the most important ore guides of prospecting for many years, in which statistical methods play an great role (Harris et al., 1999, 2000). Classical statistical methods such as univariate and multivariate analysis methods based on frequency statistics and were popular over a long period in the past (e.g. Sinclair, 1974; Govett et al., 1975; Miesch, 1981; Stanley and Sinclair, 1989). However, due to the effects of soil and vegetation cover, geochemical signatures and geophysical features obtained at the surface of the Earth can be very weak since measured values obtained by geochemical analysis are mixed with both anomaly parts which reflect deep orebody and background parts which reflect soil background effect. Classical first-order and second-order statistics will be of limited use in this condition. Higher order statistics based on fractal/multiracial theory has been developed to

deal with this problem (Cheng, 2008). Fractal was originally used to characterize self-similarity of geometric objects at different scales: i.e., amplified parts are like the whole to some degree (Mandelbrot, 1975; Cheng et al., 1994). Cheng et al. (1994) and Cheng (1996) used this self-similarity for the description of cumulative frequency, and developed concentration–area (C–A) model, which was considered as the first attempt to use fractal method to separate geochemical anomalies from background (Li et al., 2003). In C–A model, an accumulative frequency distributing graph is obtained, in which the logs of concentration and the area which own values greater than corresponding concentration are taken as abscissa and ordinate respectively. One or more straight lines can be used to fit the accumulative frequency distributing, and their slopes represent different fractal dimensions (Cheng et al., 1994). C–A model incorporates spatial association, anisotropy information and locational information into characterization of geochemical patterns, however it is of limited use in the context of changing background. Later, Cheng (1997, 1999b, 2005) proposed local singularity analysis (LSA) technology which can be seen as an application of the C–A model within a local window for local anomaly information extraction (Cheng, 2006b). According to (Cheng, 2004, 2006a), abnormally strong energy release within a very short time interval or massive emplacement of material

within a very small spatial domain can result in a singularity, and LSA is a technology to explore this singularity.

LSA, if implemented in spatial domain, is essentially a spatial neighborhood-window statistical model based on nonlinear theory with GIS-based applications. In this approach, fractal/multifractal theory is used to overcome limitations of classical statistical methods based on the assumption of normal or lognormal distribution of the data (Cheng, 1996). Application of the local window statistical method can avoid the problem that a global optimal threshold may not be suitable at every location as is generally assumed in traditional statistical methods. Because of this advantage, LSA has become widely used in the geosciences and has been established as a powerful tool for information extraction of geochemical (Cheng, 2007; Zuo & Cheng, 2008; Xie et al., 2008; Zuo et al., 2009, 2013, 2015; Liu et al., 2013a, 2013b), tectonic (Wang et al., 2012), geophysical (Wang et al., 2013; Chen et al., 2013, 2015), DEM (Zhang et al., 2014), remote sensing (Neta et al., 2010) and land-value assessment data (Hu et al., 2012). Nevertheless, none of these papers offer any case study considering anisotropy and its variability in space.

In fact, Cheng (2006a) pointed out that LSA can be implemented both based on regular windows of different shapes and contours of irregular shapes which characterize the anisotropy of geochemical patterns, and Cheng (1999a) once introduced rules for LSA application including how to build a moving window and how to set the window's parameters by using the spatial U-statistics method (Cheng et al., 1996). Chen (2007), Chen et al. (2007a, 2007b, 2014) proposed several algorithms to estimate implement LSA including an iterative approach (I-LSA) and a generalized approach accounting for anisotropies (GLSA). I-LSA produces a sequence of singularities (α) at various scales to be combined for estimation of singularity, and GLSA estimates singularity with windows in variable sizes and shapes as proposed and used by Cheng et al. (1996) for spatial U-statistics analysis. However, LSI based on U-statistics is very time-consuming because of its high complexity, and in fact very few applications have been performed based on it.

On the whole, it is not efficient to model LSA with existing software or modules, and it cannot always fit each location to use the same set of local window parameters. In this paper we develop a new program in VBA, the built-in programming language of Microsoft Office, for LSA with variable windows. Advantages of Excel VBA for LSA include: (1) it can directly call a large number of built-in Excel Functions which are efficient and easy to use (here the primary concerns are math and trig functions and statistical functions); (2) design automation of parts of the program can be achieved by the use of macro recording, which greatly benefits us the file reading and writing programming; and (3) Microsoft Office is the world's most widely used office software and modules developed in Excel VBA can be directly used by almost all Microsoft Windows users, which facilitates the application of LSA. For these reasons, Excel VBA was chosen in this paper associated with the secondary development environment of ArcGIS 10 to develop a comprehensive and virtualized module for LSA called Batch Tool for Local Singularity Index Mapping (BTLSIM). Following are the main features and advantages of this new module compared with present software tools.

(1) BTLSIM provides a batch processing for LSI. Supposing there are 40 chemical element layers, and we need to obtained their LSI layers at the local window size of 6 km, 8 km, …, 50 km, then it needs $40 \times 23 = 920$ times' manual operations. If anisotropy is considered, and further supposing there are 9 kinds of directions and 10 kinds the length ratios between the semi-minor and semi-major axes of the elliptical window, manual operations needed to be done would be

$40 \times 23 \times 9 \times 10 = 82,800$ times, which not only costs lots of time, but increases the wrong making probability. One need not worry about these problems at all when BTLSIM is performed.

(2) BTLSIM offers more window parameters, which are classified as calculation window and file window parameters, and users have more choices. E.g., if the study area is large and there are too many grids, one can increase the interval of calculation window size which can only be 1 in present software; local elliptical windows which are used to describe anisotropy can be defined arbitrarily by specifying the orientation of the ellipse's major axis, and the length ratio of major and minor axis, while we can only select four directions and the length ratio cannot be modified in existing software.

(3) Based on the multi-scale and anisotropic window parameters introduced above, one can obtain many LSI layers together with their statistical test parameter layers reflecting the significance level of LSI at each location, which makes it possible to obtain an optimized LSI (OLSI) at each location together with its self-adaptive local window parameters (SALWP) including self-adaptive local window size (SALWS), self-adaptive local window direction (SALWD) and self-adaptive local window compression ratio (SALWCR). The case study in research shows that OLSI layer has better spatial relationship with known deposits than any single LSI layers, and SALWP can indicate more tectonic and metallogenic information in the study area.

(4) Average value for a local window can be measured using not only the arithmetic mean, but also the median, which is considered as a robust statistic.

Although Excel VBA is used for BTLSIM programming in this paper, our research can provide references for people who use other programming tools and are interested in LSI algorithm improvement. More importantly, this research can benefit people who have already used LSI for geo-information extraction since BTLSIM simplifies operational processes and improves efficiency and prediction accuracy. Besides, the solutions provided in this study to deal with multi-scale and anisotropy, and the realization of anisotropic parameter mapping can also be referred by potential geosciences researchers.

2. Theory of local singularity analysis

The basic idea for LSA is to deduce a regression equation based on the logs of both window size and the concentration within it so obtain LSI from the slope of the equation, and before that the most important choice in LSA consists of the selection of an appropriate window size: too small window size captures more detailed information but can incorporate random noise, whereas too large window size results in relatively low resolution maps. LSI is obtained by means of the following power-law model in two-dimensional space:

$$\rho(\varepsilon) = c\varepsilon^{\alpha-2} \tag{1}$$

where c is a constant, representing a density measure that is independent of scale, ε is the local window size, ρ is average density within the local window of size ε, and α is the singularity index. By using the least squares method, α can be estimated as the slope of a best-fitting straight line for the relation between $\log \rho$ and $\log \varepsilon$. The local singularity index α has the following properties: (1) when α is close to 2, element concentration is substantially constant, regardless of window size; (2) $\alpha < 2$ represents concentration value increase for reduced window size, indicating
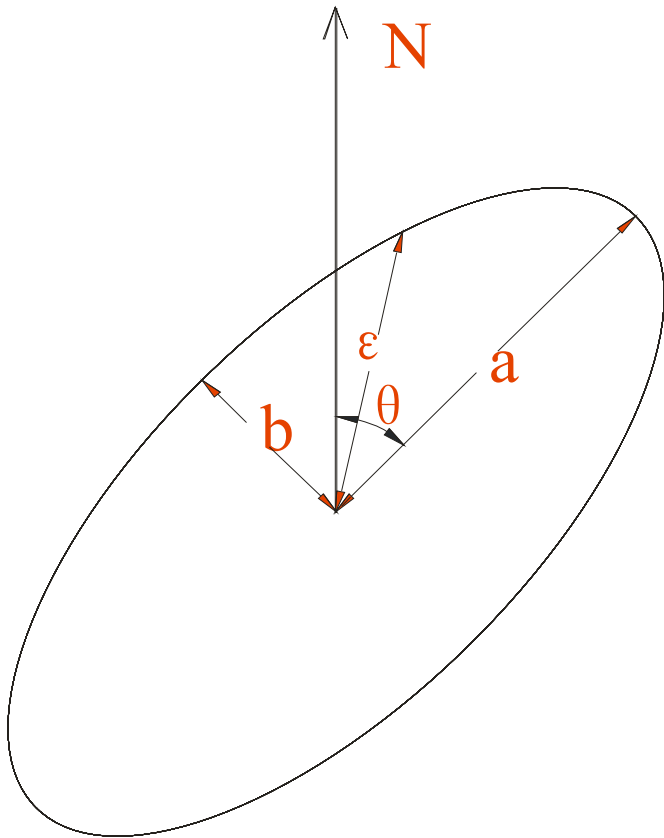
Fig. 1. Anisotropic parameters for elliptical window.

elliptical window with variable shape, orientation and size, it can be used for measuring anisotropic singularity as shown in Fig. 1 (Cheng, 1999a). For an elliptical window, Eq. (1) becomes

$$\rho(\varepsilon(a, \ \beta, \ \theta)) = c(a, \ \beta, \ \theta)\varepsilon^{\alpha-2}(a, \ \beta, \ \theta) \tag{2}$$

where ε is the equivalent radius with $\beta = b/a$ being the ratio of semi-minor axis (b) to semi-major axis (a) and θ representing azimuth. Equivalent radius is used for window characterization size rather than semi-major or semi-minor axis. The singularity index is obtained as the slope of the best-fitting line for the log–log relationship between window size $\varepsilon(a, \ \beta, \ \theta)$ and average content $\rho(\varepsilon(a, \ \beta, \ \theta))$. In this study, this kind of anisotropic window is also included in BTLSIM as an extension of isotropic window. Besides, a deeper contribution of BTLSIM is that it can obtain different anisotropic parameters for different locations, which is important to perform LSI in more complicated area, and to map anisotropic parameters for further information mining.

3. Models

Elliptical parameters are used to express anisotropy in BTLSIM. The main part of BTLSIM is implemented with Excel VBA, while other procedures are performed with ArcToolbox and Python in ArcGIS 10.0 Desktop. Fig. 2 shows the processing flow of BTLSIM taking geochemical exploration data for example.

*a, LSA is local singularity analysis; *b, LSI is local singularity index. The dotted rounded rectangle at the top contains all modules developed with ArcToolbox and Python in ArcGIS 10.0 Desktop; dotted rounded rectangle at the bottom contains the modules developed based on Excel VBA. The rounded rectangles colored in yellow are resulting maps to be shown in ArcGIS 10, while the ones colored in green are operational process documents produced by BTLSIM.

3.1. Data format transformation

Grid files must be transformed into ASCII files in order to perform BTLSIM, while the resulting ASCII files of BTLSIM have to be transformed into ArcGIS GRID in order to be shown in ArcGIS. Auxiliary tools have been developed with ArcToolbox and Python,

enrichment in the vicinity during the process of mineralization; and (3) when $\alpha > 2$, concentration decreases with the decrease of window size indicating depletion.

The window can be of different shape, e.g. square, circular or elliptical (Cheng, 1999a) and can incorporate even contours of natural shapes determined by the data (Cheng 2006a). For a regular window, it can be determined by the size ε representing length of side, radius, or equivalent radius, respectively. As an
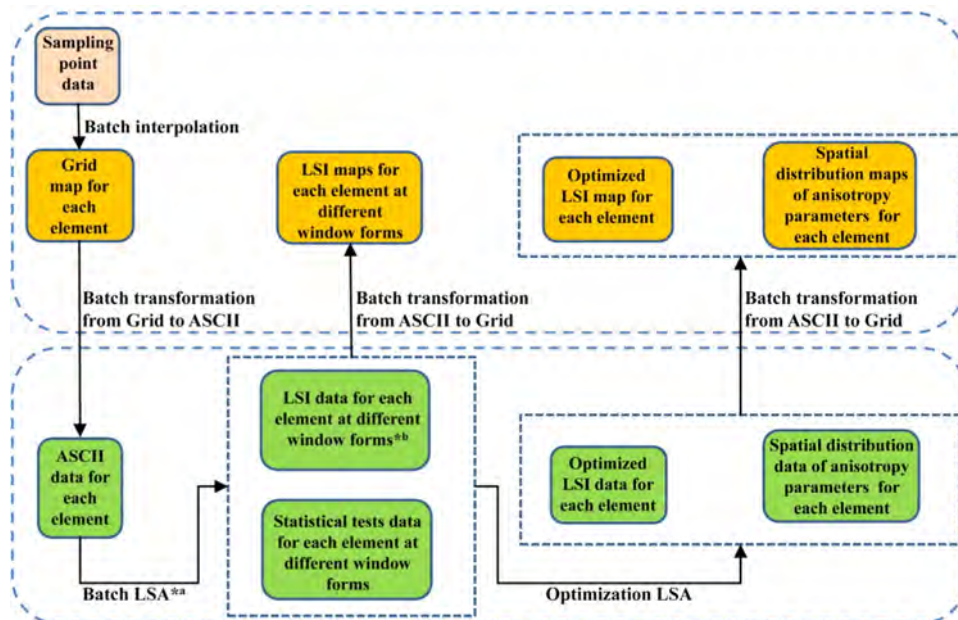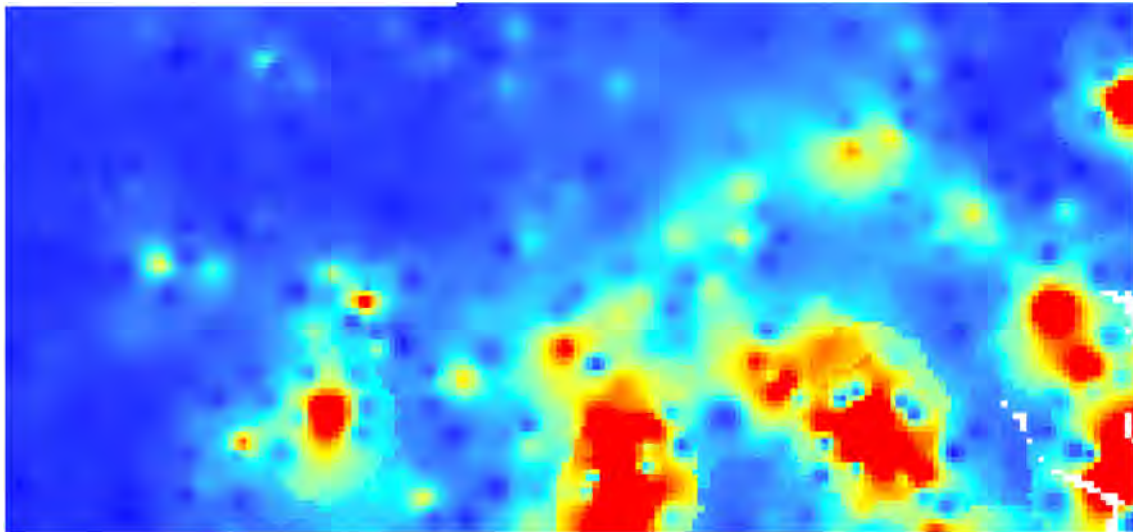

Fig. 2. Processing flow of Local Singularity Index Mapping.

(a) ArcGIS GRID

```
ncols          183
nrows          227
xllcorner      302869.799949
yllcorner      4832488.7674181
cellsize       500
NODATA_value   -9999
-9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -9999 -99
3 2.586167 2.520388 2.543285 2.686834 2.871292 3.152994 3.510174 3.976501 4.600021 5.40504 6.306086 7.007425 7.
3.264577 3.290315 3.317501 3.346402 3.320493 3.352246 3.391467 3.441835 3.507206 3.59128 4.107793 4.260533 4.42
.720981 2.715063 2.715357 2.712064 2.725328 2.713479 2.676635 2.697529 2.735846 2.783751 2.832067 2.873323 2.90
3.247118 3.275149 3.303924 3.332295 3.362222 3.342489 3.379276 3.428896 3.496683 3.588063 3.708364 4.271666 4.47
279 2.662559 2.666054 2.677845 2.677922 2.676714 2.64752 2.638371 2.639255 2.691802 2.756416 2.819371 2.873536
3.22838 3.261044 3.292708 3.320915 3.347013 3.331369 3.362991 3.409097 3.476454 3.572168 3.703945 3.880105 4.50
2.590795 2.614074 2.647715 2.650824 2.633387 2.579356 2.556361 2.578927 2.650561 2.733505 2.810199 2.87639 2.92
3.206643 3.2489 3.28699 3.315396 3.335014 3.354774 3.342819 3.382515 3.446217 3.542194 3.680217 3.87202 4.51027
2.524057 2.562067 2.621541 2.643774 2.611905 2.53727 2.502671 2.551145 2.653437 2.758886 2.806242 2.880222 2.94
3.178147 3.238655 3.291258 3.320137 3.327601 3.33198 3.350227 3.43011 3.406744 3.498352 3.635476 3.832065 4.106
02527 2.548031 2.620417 2.669504 2.634529 2.560457 2.527947 2.576644 2.672891 2.762974 2.800093 2.876683 2.9614
3.132561 3.229516 3.314239 3.342777 3.321068 3.299843 3.307717 3.376043 3.444667 3.54749 3.570914 3.759082 4.02
.59277 2.669737 2.707874 2.692083 2.64869 2.62644 2.664364 2.719113 2.75377 2.76688 2.848028 2.996875 3.074427
3.043701 3.212775 3.376351 3.401144 3.291512 3.229224 3.249941 3.29096 3.381589 3.472096 3.605399 3.792004 3.89
3501 2.759374 2.771704 2.771021 2.752209 2.741129 2.7412 2.724528 2.685009 2.693589 2.800441 2.986498 3.129539
2.862912 3.158756 3.521778 3.576851 3.126454 3.05284 3.181745 3.243902 3.317893 3.389716 3.503592 3.665571 3.87
78292 2.799396 2.855882 2.854793 2.859989 2.849542 2.828436 2.783112 2.689395 2.574846 2.560054 2.711956 2.9787
2.600141 3.03825 3.760943 4.327147 2.734806 2.918211 3.170784 3.208155 3.214301 3.29441 3.39036 3.531013 3.7009
4 2.963373 2.981364 2.956469 2.944536 2.909261 2.83153 2.691533 2.546116 2.522049 2.71068 3.052587 3.406194 3.7
```

(b) ASCII Code

Fig. 3. Data format transformation between (a) ArcGIS Grid and (b) ASCII, obtained through printscreen.

with which grid and ASCII can be transformed into each other in batches in accordance with a predetermined directory (Fig. 3).

3.2. Main module

In this study the main module design of BTLSIM is based on Excel VBA. Fig. 4 provides two user interfaces which show all parameters and how to set them in BTLSIM. One is for local singularity index batch calculation with isotropy or anisotropy parameters, and the other is for optimized window parameter selection.

3.2.1. Multiple-file design

A source folder should be created first, so that all ASCII files at a specific location can be read and saved individually into a nested two-dimensional array for further processing. Analogously, a result saving folder should be assigned, so that the resulting data can be saved successively as ASCII files from another nested array.

3.2.2. Multiple-local-window design

Please keep in mind that "window" in this paper means sliding local window, i.e., a range in which LSI is calculated for the current point (grid). This part involves two types of window: calculation windows within each of which the average content will be calculated, and file windows for each of which a LSI layer will be obtained. A circular window example is given in Fig. 5 for understanding their interrelationship. The point to be calculated for LSI value is called current point, which is located at the center in Fig. 5; and the radius of each concentric circle is called window size in LSA. Fig. 5(a) shows that the initial interval between any two adjacent concentric circles is 1 unit (pixel), which is determined by the original resolution of the grid file. The increment of the calculation window can be set as 1 grid, that is the way in existing software when LSI is performed (see Fig. 5(a)). Nevertheless, it is too expensive to deal with big data since it needs higher computation cost. In BTLSM, the increscent of calculation window can be determined as any natural numbers, which makes it possible to choose a suitable increment of calculation windows according to the initial resolution and the required precision. Fig. 5
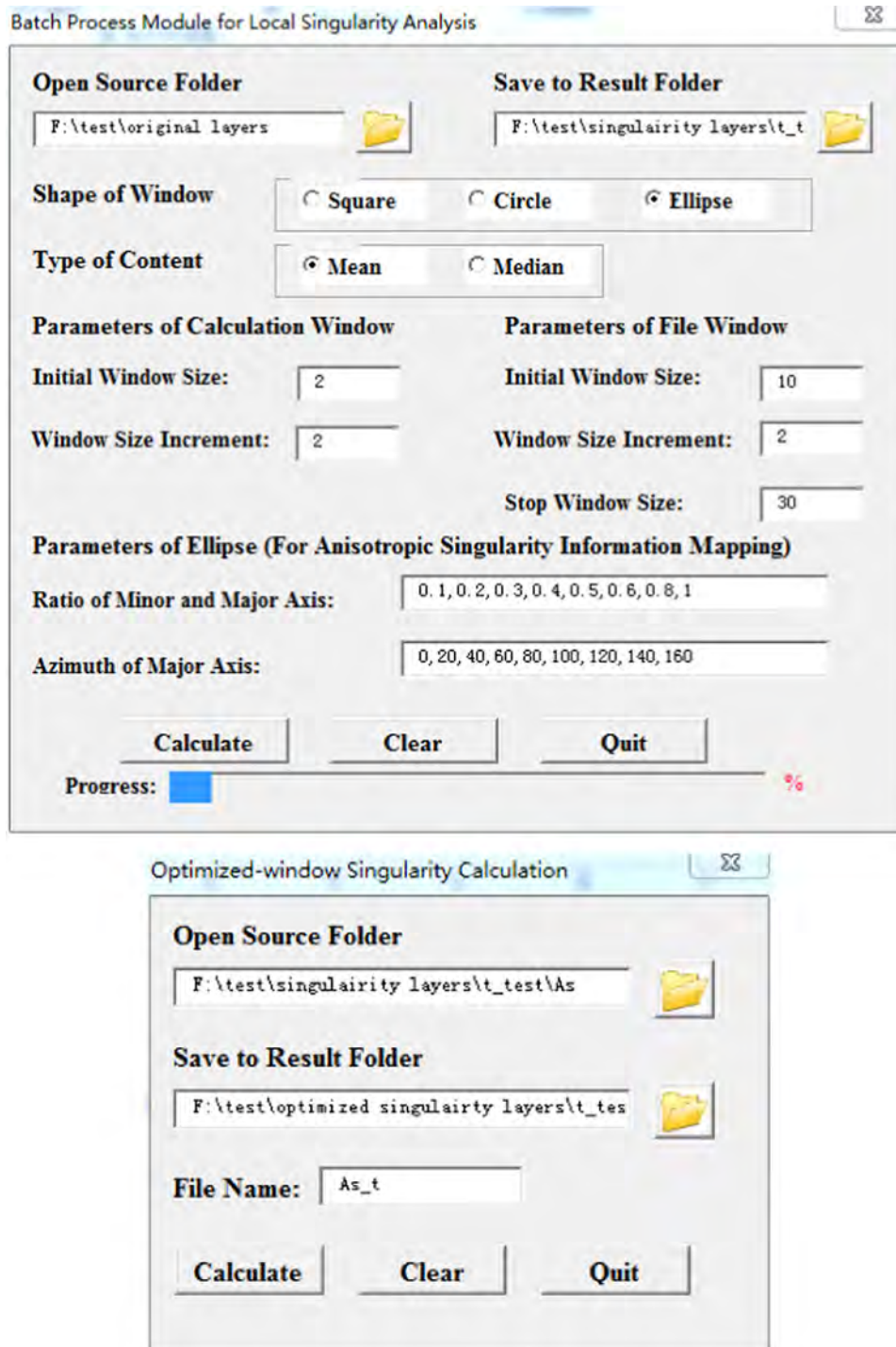
Fig. 4. User interfaces.

(b) shows the distribution of calculation windows (colored in yellow) when the increment is 2 grid, and in this condition the average content within the 1st, 3rd, 5th, 7th, 9th, 11th, 13th, 15th and 17th circles will be calculated respectively. Theoretically LSI layer could be obtained as long as there are more than 2 levels of calculation windows, because regression models could be established with 3 or more local window sizes which corresponds to different average contents. But sometimes we do not want to get LSI layer at each calculation window since it will result in too many files and cost lots of time and storage space. We can choose parts of the calculation windows as file windows, and Fig. 5 (c) provides a way. In Fig. 5(c), the window size of file window is

grown from 5 units to 17 units with an interval of 4 units, which means only LSI maps with maximum window size of 5, 9, 13 and 17 will be obtained. When the window size of file window is 5, the log values of the average contents within the 1st, 3rd, 5th circles, and the log values of corresponding window size allow fitting a straight line in rectangular coordinate system via the least squares method. Then LSI for the maximum window size of 5 can be obtained, and the LSI maps for window size of file window as 9, 13 and 17 can be obtained similarly. It is noted that the average value within each calculation window is calculated only once, although the results are used for the calculation of local singularity indices for different file windows.
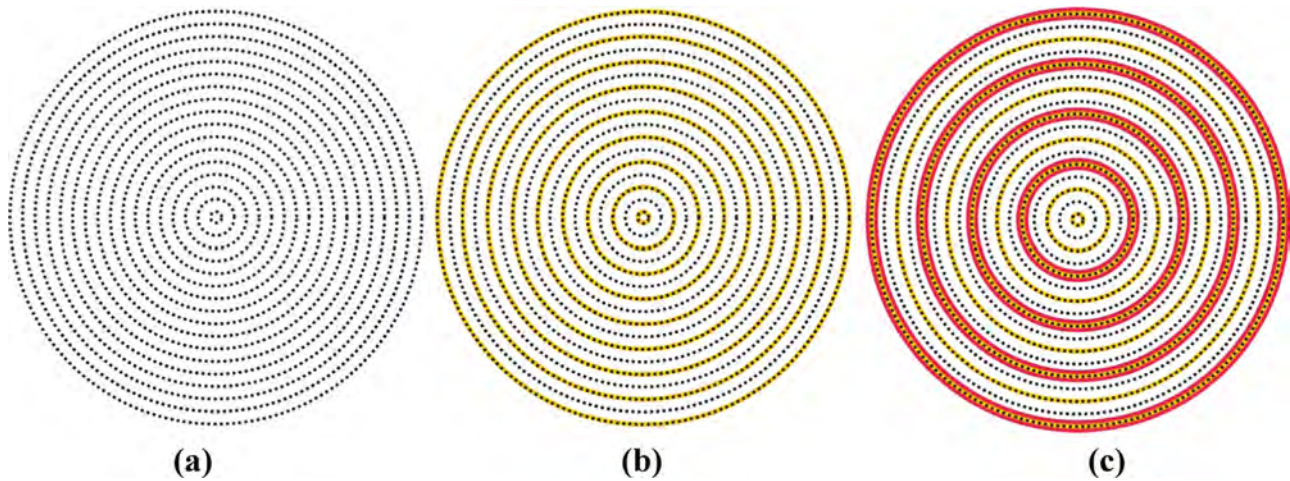
Fig. 5. Multiple-window for (a) initial windows, which reflect the original pixel size; (b) calculation windows, which reflect the expansion of present window at the speed of double original pixel size; and (c) file windows, which reflect that the LSI for certain LSI files would be saved. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

3.2.3. Local window shape

Three kinds of local window are provided here: i.e., square, circular, and elliptical. Square window procedures are similar to those for circular windows as introduced in preceding section, because both are isotropic windows. Nevertheless, the elliptical window is used to describe anisotropy, which can express more information, not only size but also compression and directivity. In the applications of this paper, window size is measured by means of the length of semi-mayor axis for the elliptical local window.

3.2.4. Content calculation methods within a local window

A common practice to express the content for a local window is using the mean value. However, the mean value can be affected by outliers, and it sometimes is better to use the median instead of the mean value. Therefore, both mean and median options are provided.

3.2.5. Anisotropy parameter design

When a square or circle is used to specify the local window, the only parameters that can be changed are concerned with the window size including initial window size, growing window size increases, and the maximum half-indow size. However, there will be more parameters to be set when an elliptical window is used to describe the anisotropy of spatial distribution. In a two-dimensional coordinate system, when the location is given, three parameters being the length of the semi-major axis (i.e., the window size, as introduced in last session), azimuth, and ratio of the lengths of semi-minor and semi-major axes can be used to uniquely determine an ellipse. These three parameters are changeable and can be defined all at once.

3.2.6. Optimizing the local singularity index

Different kinds of singularity patterns can be obtained through different local window settings. For an elliptical window, different singularity patterns can be measured by varying not only the size but also the semi-major axis azimuth and the length ratio between the semi-minor and semi-major axes. So far all these applications are based on global criteria and the LSI maps are obtained based on the same local window parameters, and we can choose the best one from these maps according to their spatial correlation with the deposit layer. In fact, the optimized anisotropy parameters are changed everywhere. When a series of LSI maps are obtained using different local window parameters, statistical test parameters are also calculated, including goodness of fit (R^2) and

probability of t test. Thus it is possible to obtain an relatively optimized LSI value at each location according to R^2 or the confidence limit of t test; and the corresponding optimization parameters can also be recorded as layers, i.e. the maximum range, the azimuth of the semi-major axis, and the length ratio between the semi-minor and semi-major axis.

3.3. Key function

Build-in Excel functions have benefited our design a lot, among which *Linest* is the core function for calculation and optimization of LSI. The input of *Linest* consists of two vectors representing the logarithmically transformed window sizes and the average contents in the corresponding local window, and the output of *Linest* is a 5×2 array (see Table 1).

4. Case studies

The test data in this paper were taken from Cheng (2008)'s case study. The study area (≈ 7780 km^2) is located in western Meguma Terrain of Nova Scotia, Canada. The lithological units in the study area are mainly Cambro-Ordovician low-middle grade metamorphosed sedimentary rocks and Devonian granitoid intrusions (Sangster 1990; Ryan and Ramsay 1997); the former are mainly NE–SW striking lower sand-dominated flysch Goldenville Formation and upper shaly flysch Halifax Formation, folded during Devonian granitoid intrusion emplacement (Kontak et al. 1998). The South Mountain Batholith (SMB), which is a complex of multiphase granites, occurs mostly in the northern and southern parts of the study area (see Fig. 9). Significant Au (aurum), W (wolfram) and Sn (stannum) mineralization and mineral deposits have been

Table 1
Output of Linest function[*].

	Column 1	Column 2
Row 1	$a1$	b
Row 2	$S(a1)$	$S(b)$
Row 3	R^2	$S(y)$
Row 4	t	d_f
Row 5	SSR	SSE

[*] Extracted from help text of Excel (with a slight change): $a1$ is the opposite of LSI, $S(a1)$ is standard error of LSI, $R2$ is coefficient of determination. $t = a1/S(a1)$ is the observed value for t-test with n-2 degrees of freedom.
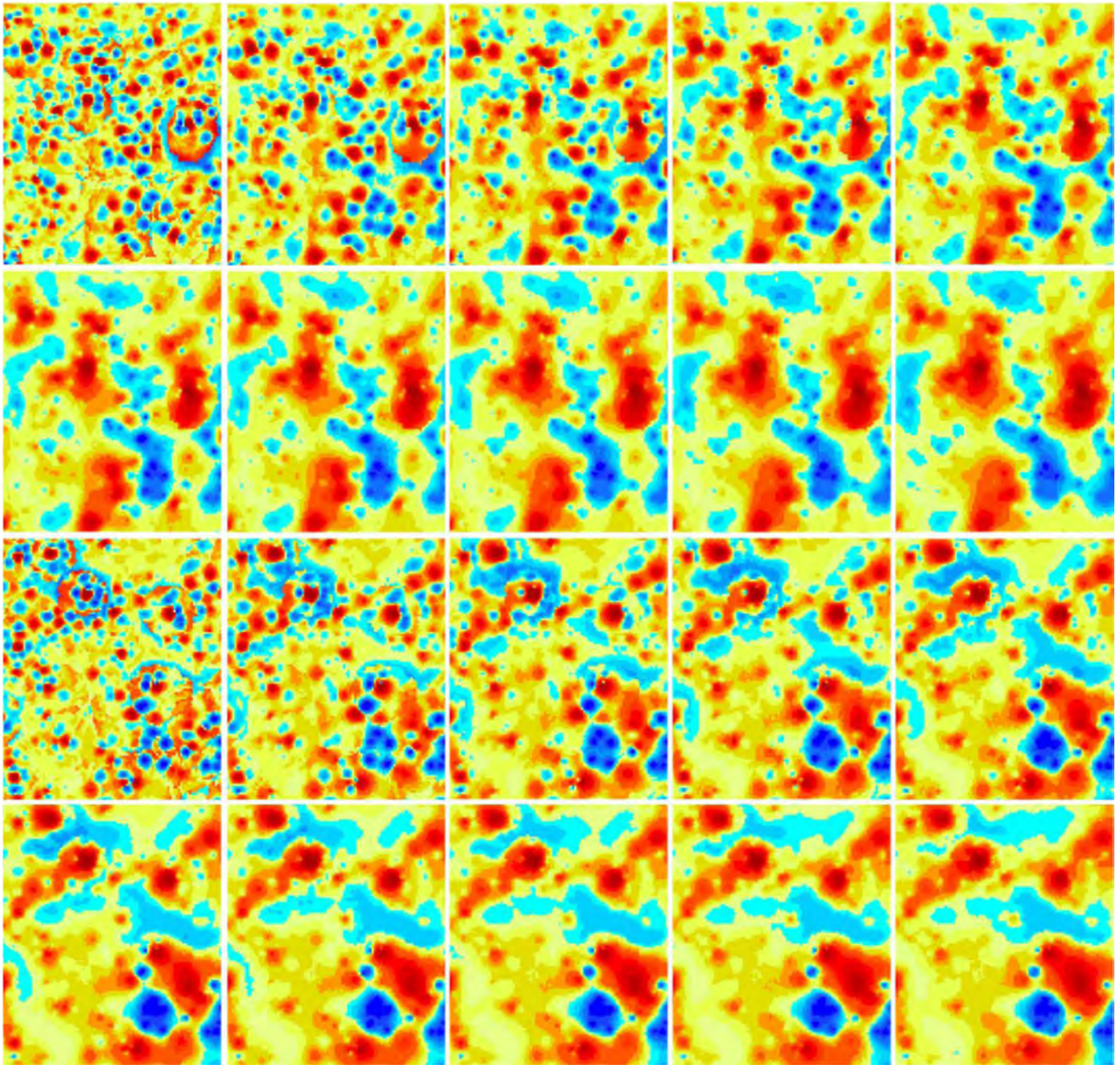
Fig. 6. Print screens of Local singularity index maps for square window. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)

found in this area, including 20Au deposits. With respect to geochemical exploration, there are 671 lake-sediment geochemical samples with sampling density as about 1 sample per 5 km². Former research has shown that both As (Arsenic) and Au concentration values have significant spatial relationship with the occurrences of Au deposits (Xu and Cheng, 2001). Therefore, all tests in this work are done on the relationship between Au deposits and these two elements, which are represented in the form of 500 m × 500 m grid layers.

4.1. Local singularity maps for square window

Firstly, the grid layers of elements As and Au were transformed into ASCII files. Secondly, input and output files were designated. Thirdly, the window shape and the content type were set as square

and mean respectively. Finally, the initial window size and the increasing window size for singularity calculation were set at 1 and 2; and the initial window size, the increasing window size and the stop window size for singularity files were set at 5, 4 and 41 respectively. As is discussed in Section 1, the traditional approach for LSI is to determine a set of local window parameters according to experience for the whole study area, e.g., 13 km is considered a good scale to extract geochemical anomaly in this study area. Nevertheless, it is common that a universally suitable local window may not exist in the whole study area, and that is why BTLSIM is developed in this research. In the new module, a discrete interval (i.e., from 5 to 41 as is shown above) is used instead of an isolated point (i.e., 13 according to experience), which can well combine prior knowledge and statistical quantitative laws. Different LSI maps of As and Au were obtained reflecting local anomalies at different spatial scales (see Fig. 6).
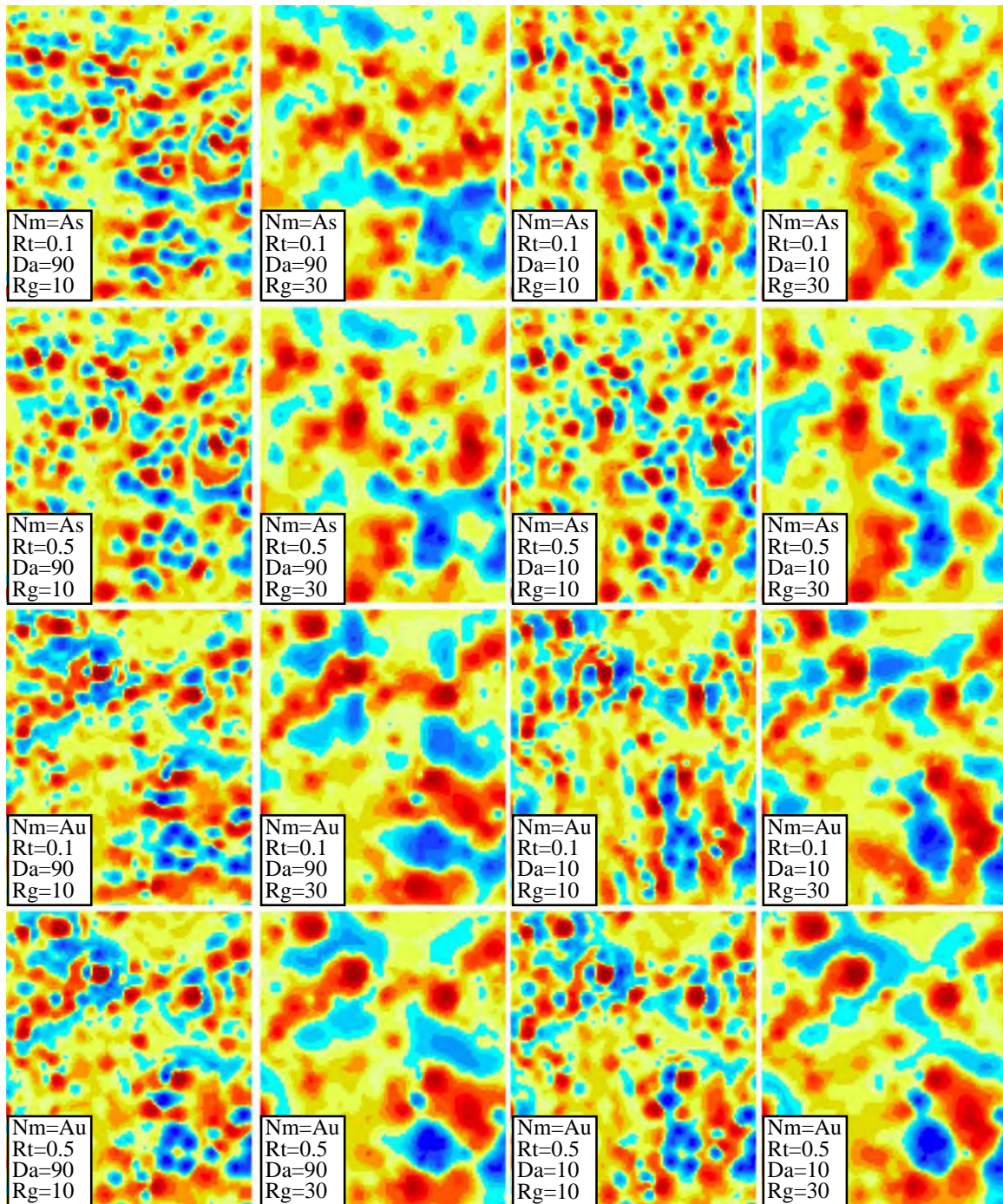
Fig. 7. Print screens of local singularity index maps with elliptical window.

Pictures in the first two rows and the last two rows are print screens of different window-size local singularity index maps for elements As and Au, respectively. From top to bottom, and from left to right, the maximum values of window size are 5, 9, 13, 17, 21, 25, 29, 33, 37, and 41 respectively. The hot colors (from red to orange according to the severity) represent high singularities while the cool colors (from blue to yellow according to the severity) represent low singularities. These pictures reflect changes of singularity form. On the one hand, the smaller the maximum window size is set, the more detailed the singularity becomes, but more noise is included; on the other hand, the larger the maximum window size is set, the more regular the singularity shapes become, but small size singularities may be filtered out.

4.2. Local singularity maps for elliptical window

The first step again was to transform the grid layers into text files and to designate the input and output folders. The type of local window used here was elliptical and content within local window was taken as mean value. More parameters have to be determined when an elliptical window is used to capture anomaly information due to anisotropy. The basis of determining parameters for an elliptical window is similar to Section 4.1, except that there are more parameters and we should also define discretization schemes for the azimuth angle and the compression for an ellipse. Here initial window size was set as 2 instead of 1 based on our understanding that the range of 3×3 could weaken the
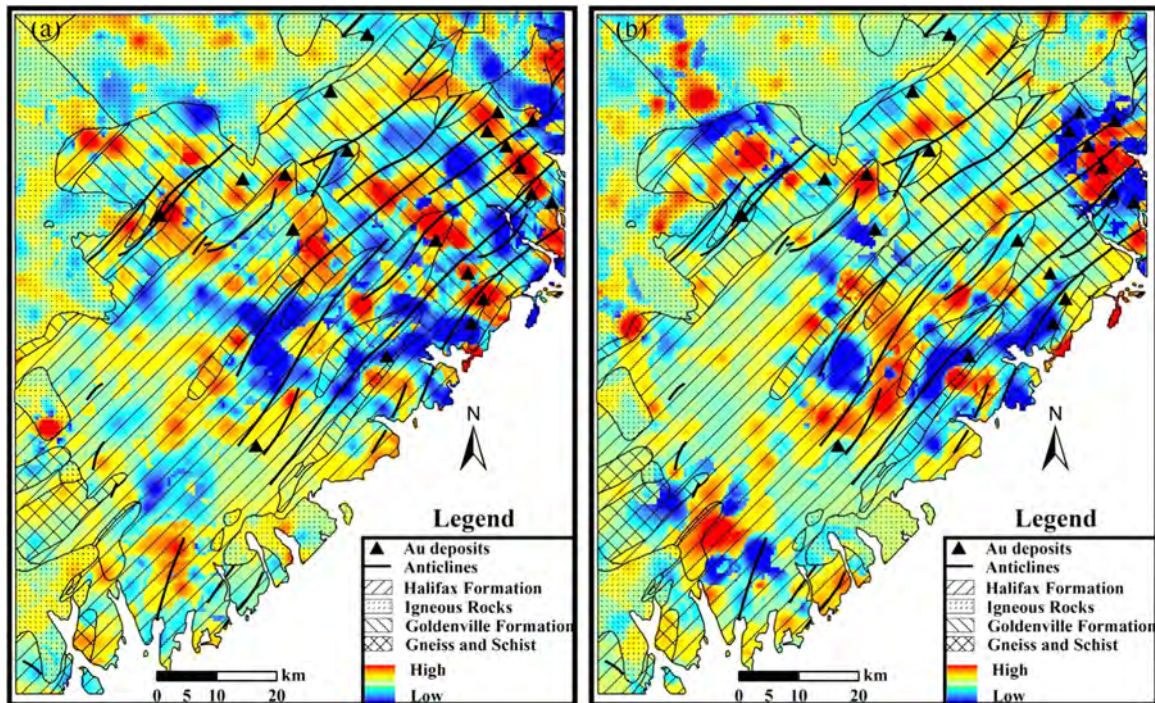
Fig. 8. Optimized local singularity mapping for (a) As and (b) Au.

effect of outliers and improve the precision of regression curve equation; increasing window size for singularity calculation were also set as 2, because increasing the increment of increasing window size can reduce the amount of computation and improve the operation efficiency. Initial window size, increasing window size and stop window size of file were set as 10, 2 and 30 respectively. That is because 13 km is considered as an empirical value with the scale of 1:200,000 and we choose a smaller value (10 km) for conservative estimation, and 30 km is considered as the maximum range for geological anomaly scope, and our set can guarantee obtain optimized LSI from 10 to 30. Besides, variogram, which is the basic tool of geostatistics can also be used to determine the ranges for local window size. Minimum and maximum value of the length ratio between the semi-minor and semi-major axes of the elliptical window were set at 0.1 and 1, with increments of 0.1 for equal dividing. Minimum and maximum value of the azimuth angle of the ellipse semi-major axis were set at 0° and 160°, with increments of 20°, which is also for equal dividing. Because the direction of the semi-major axis in an elliptical window is perpendicular to the trend of original element contents, we have used the singularity direction instead of the semi-major axis direction. Screenshots of parts of all 1980 LSI maps are shown in Fig. 6. It can be seen that the singularity patterns are affected greatly by the azimuth and the length ratio between semi-minor and semi-major axes of the elliptical window. The resulting singularity patterns also are related to the window size, as they were for the square and the circular windows. An elliptic window makes it possible for users to extract certain forms of mineral anomaly; e.g., if singularity information for a certain direction is to be extracted, the corresponding azimuth parameter should be set for this direction (Fig. 7).

Pictures in the first two rows and the last two rows are print screens of different window-size local singularity index maps for As and Au, respectively. Element name and elliptical window parameters are shown in the left corner of each picture: Nm (name) is short for element name; Rt (ratio) represents the ratio of major and minor axis of the ellipse; Da (direction angle) means azimuth angle of the ellipse's semi-major axis, in degrees; Rg

(range) represents maximum value of the semi-major axis, which represents the range of the singularity, in grid numbers.

4.3. Optimized local singularity mapping

Based on a series of local singularity maps obtained under different window parameters, optimized LSI maps were obtained according to t-statistics (see Fig. 8a and b. As is described in Table 1, LSI has 1 degree of freedom when t test is performed since $n=2$. It can be seen from Fig. 8 that both overall trend and local details are captured, with the maxima showing good spatial correlation with the Au deposits. It could also be seen from Fig. 8 that although the study area is totally controlled by northeastern structure, beaded anomalies stretching northwestwardly s hows much closer relationship with the known Au deposits, which is in good agreement with previous studies. In order to compare optimized LSI and the single window parameter maps, results of further tests for the element As are shown in Fig. 9, for which 30 maps were selected from 902 single-parameter based LSI maps.

Fig. 9(a) shows the known deposit numbers located at the top 10% area according to the LSI maps for the element As based on different elliptical windows. From the left to the right, four clusters of pillars which represent different ratios of minor and major axes suggest self-similarity in the first three clusters, and this suggests that the spatial distribution of the anisotropy parameters does have certain rules to follow. The fourth cluster is incomplete and only the parameter of window size works. This is because when the ratio between minor and major axes is 1, an elliptical window reduces into a circular window. Among all three elliptical parameters, direction provides most discrimination, and the singularity maps with azimuth of 120° (which is close to the optimum direction in Fig. 10(a) show higher scores. When the optimum direction is determined, it can be seen that a smaller length ratio between minor and major axes can leads to better performance. Regulation of the lengths of major axes is difficult because it is hard to determine a single optimal window size for the whole study area. Thus it is necessary to find a best local window for every location in the study area. The optimized LSI layer shows
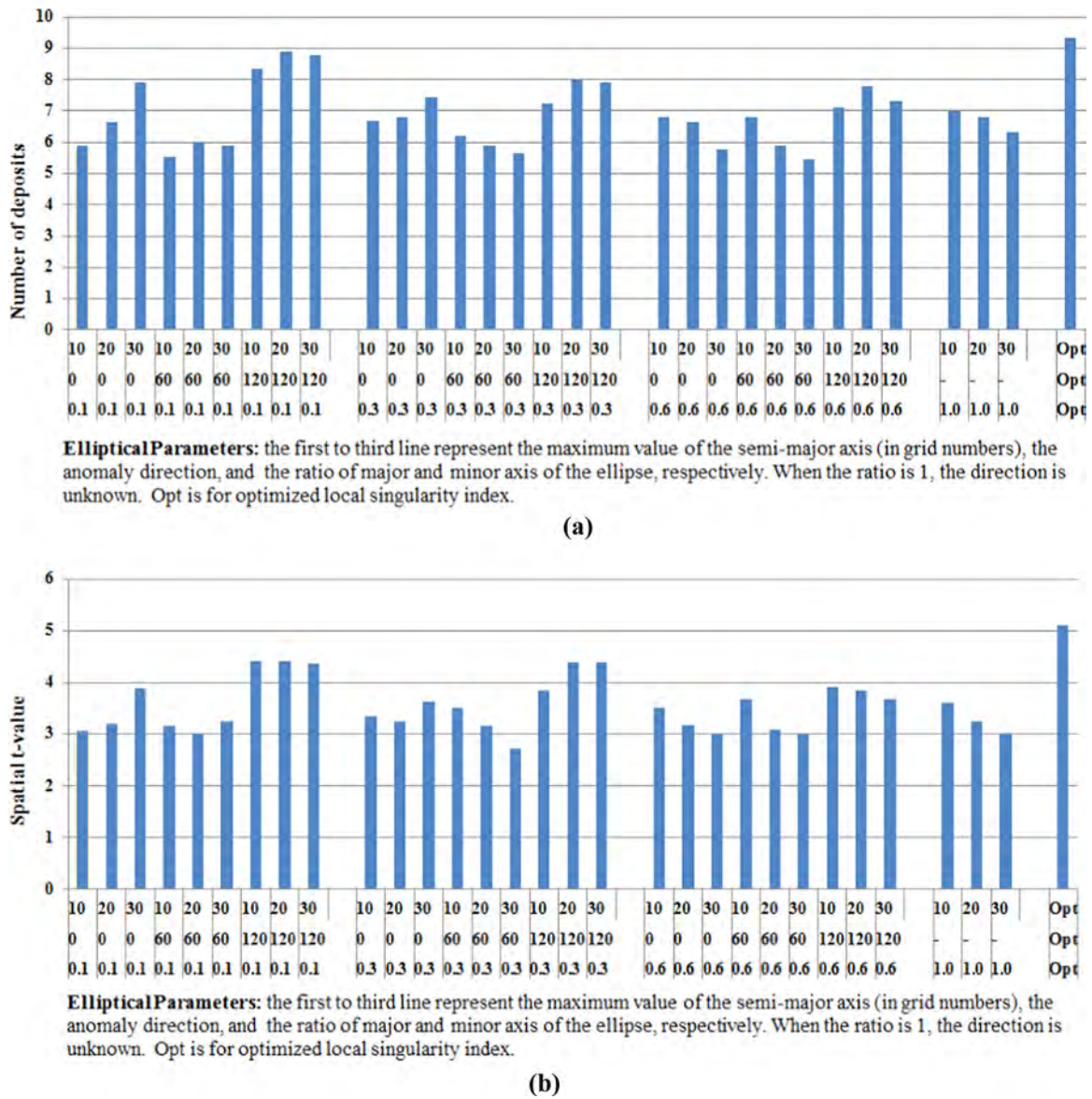
Fig. 9. Performance of optimized LSI map and single local window parameter maps according to (a) known deposit numbers located at the top 10% area, and (b) the maximum *t*-value.

higher score than any LSI layers based on single local window parameters. This further indicates that the optimizing method is not only necessary, but also useful for information extraction in mineral exploration. In order to further verify the significant for the above observation, spatial *t* test developed by Agterberg and Cheng, 2002 is also performed here. In the spatial *t* test, a bigger t value means stronger spatial relationship between two layers. The *t*-value in Fig. 9(b) shows similar regularities and the optimized LSI has the largest *t*-value. In Fig. 9(b), *t*-values on each map are obtained by firstly reclassifying the grids into 20 classes based on equal-area method, and then determining the largest *t*-values using GeoDAS software.

It should be noticed that all LSI maps were obtained without deposit training. Under this condition, any improvement in best area score or *t*-value will lead to better prediction, without the problem of over-fitting.

In addition, maps which reflect the anisotropy of As and Au were also obtained. These include the spatial distribution of window size (variable range), major axis azimuth of elliptical window, and ratio between minor and major axes of the ellipse (see

Fig. 10a–f). Such maps are of significance in detecting the structure of spatial anisotropy for geochemical elements.

Pictures in the first and second rows are spatial anisotropy parameters maps for As and Au respectively. Pictures in the first column are for the mapping of azimuth angles, in degrees, which reflect direction of the anisotropy; the second column maps show the range of semi-major axis, in meters, which reflect the size of singularity; the last column shows maps for the ratio of the length between the minor and major axes of the elliptical window, and reflects the intensity of anisotropy.

In this study area, there exists dominating anisotropic trends; e.g., the approximately 160° direction controlling almost the whole study area is stable whereas other directions are located in corridors between areas for this main direction. Anisotropy parameters such as preferred direction can become a powerful factor to improve mineral prediction.

Taking the element As for example, a histogram representing the grid counting for different directions is shown in Fig. 11. It can be seen that the SSE–NNW direction with azimuth of about 160° constitutes the majority of the total grid numbers. An amplified map representing anisotropy parameters for the black rectangle in
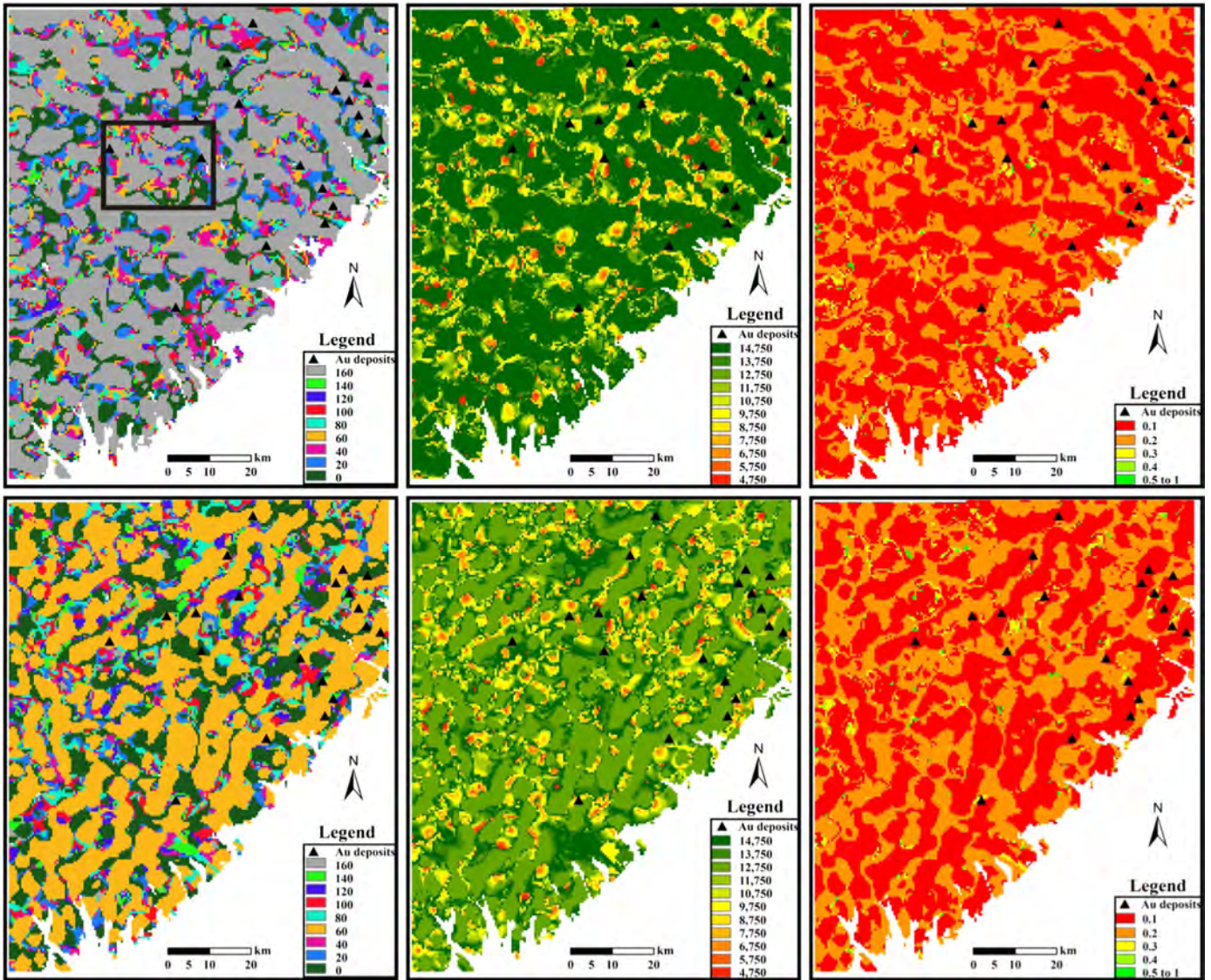
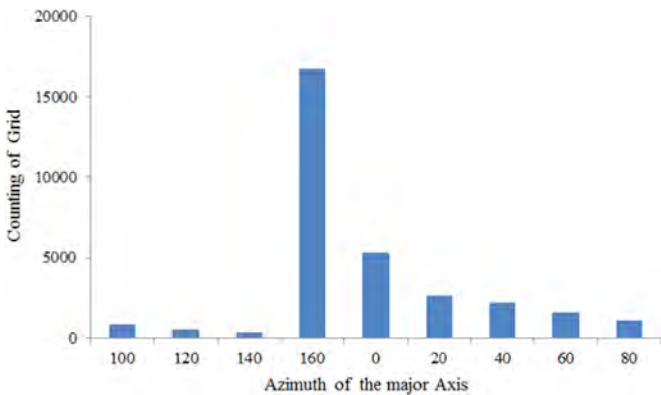**Fig. 10.** Spatial anisotropy parameters mapping.

Fig. 11. Grid counting for different fitted directions.

Fig. 10(a) is shown in Fig. 12, for which only the SSE–NNW direction is retained. It can be seen from Fig. 12 that spatial anisotropy in the SSE–NNW direction is dominant.

Red points represent deposits. For the purpose of clarity, the lengths of semi-minor and semi-major axes of the ellipse were reduced 40 times.

4.4. Discussion

In this case, Optimized LSI not only shows better predicted results than any single-window LSI layer, but also provides layers for anisotropic parameters, which have the potential to display more information on geology and mineralization. Since LSA is a non-training model and performed without known Au occurrences, any improvement on prediction performance is objective and credible, and there is need to worry about over-fitting.

5. Conclusions

In this paper, Excel software, together with the development method VBA, was used to build the BTLSIM software module. Several objectives were achieved: (1) BTLSIM reduces manual operations and improves efficiency; (2) it offers more parameter selections for LSA allowing the use of different types of local windows including anisotropic windows to explore different forms of singularities, and both mean value and median value can be used to represent the average content for the local window; and (3) it presents a relatively self-adaptive local singularity determination algorithm which can result in an optimized LSI map,
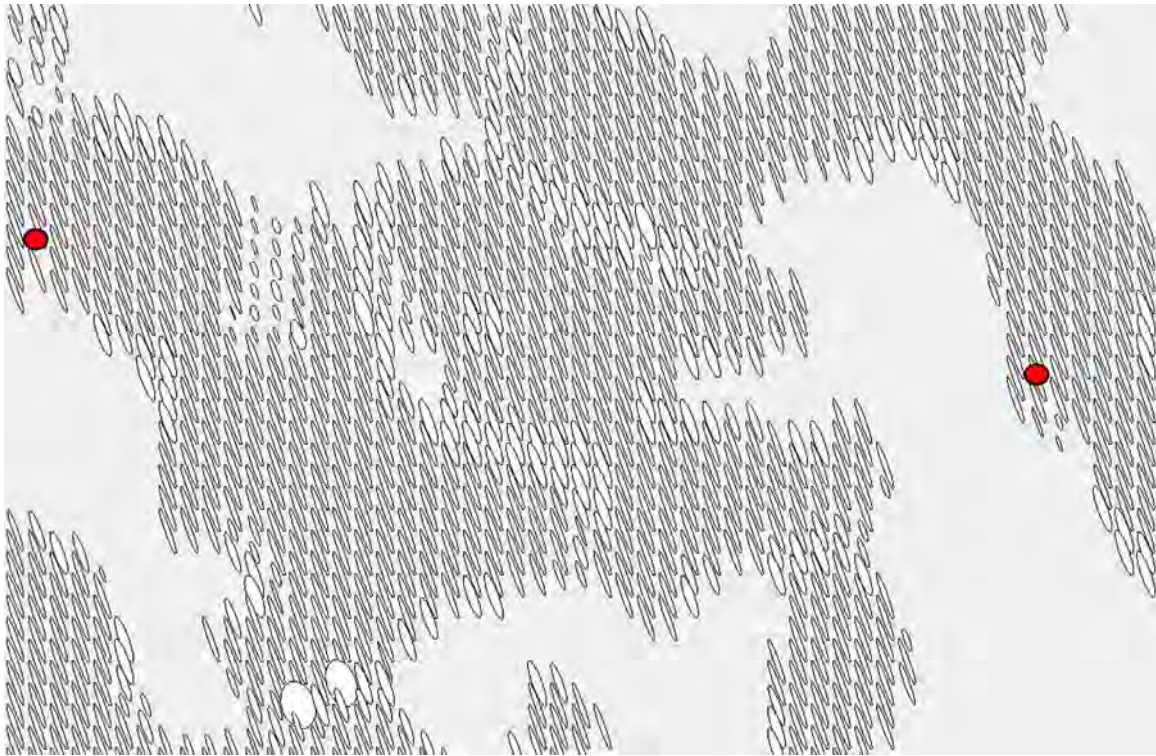
Fig. 12. Best ellipses for the calculation of local singularity index in space according to *t*-test.

providing three kinds of parameter layers for variable range, direction, and compressibility of anisotropy in space, respectively.

The case study has shown that optimized LSI maps have better spatial relationship with Au deposits than single-window based ones, which means optimized LSI is an improvement of LSI. And anisotropy layers obtained along with the optimized LSI layer can benefit further research on the spatial structure of geoscience variables.

Another advantage of BTLSIM is that the widespread availability of Excel will facilitate its usage since no extra software installation steps are needed, and it has been made sure that BTLSIM could be used in different Excel versions (from Excel 2007 to Excel 2016).

The limitations of this research include that we are not so clear about the meaning of the anisotropic patterns other than the domain direction.

Acknowledgments

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.cageo.2015.12.012.

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Economically motivated food fraud and adulteration in China: An analysis based on 1553 media reports

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ABSTRACT

Based on 1553 media reports on food safety scandals and concerns, we conducted an aggregated analysis on economically motivated food frauds and adulterations in China. A systematic approach is used to analyze the country's food safety concern in terms of fraud type, implicated foods, adulterants, contaminants and abnormal conditions, and concerned food sources. This study indicate that economically motivated food fraud and adulteration was an emerging and serious food safety problem in China. The results of the study can be used not only to analyze food safety risks but also to prioritize target areas for food policy-making and enforcement of food safety regulation.

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1. Introduction

With human unawareness and negligence, microbiological, chemical and physical hazards can accidentally enter our foods, causing foodborne illnesses and deaths. While accidental food contamination of these hazards has always been an issue of food safety, a growing concern is in the introduction of hazards by deliberate human actions known as food fraud or economically motivated adulteration (FF/EMA) (Everstine, Spink, & Kennedy, 2013; Moore, Spink, & Lipp, 2012; Tähkäpää, Maijala, Korkeala, & Nevas, 2015). Recent notorious examples of FF/EMA that have drawn great attentions around the world include the 2008 incident of intentional tampering of infant milk formula with melamine in China (Guan et al., 2009; Qiao, Guo, & Klein, 2012; Xiu & Klein, 2010) and the 2013 horsemeat substitution scandal in Europe (Bouzembrak & Marvin, 2016; Tähkäpää et al., 2015). Therefore, analyzing, communicating and managing risks from FF/EMA have become important tasks for food regulators and researchers in the interests of consumer protection and food safety. In order to better understand FF/EMA, several databases such as the EMA food fraud database, the United States Pharmacopeial Convention (USP) food fraud database, and the Rapid Alert System for Food and Feed (RASFF) have been created to document FF/EMA incidents

(Bouzembrak & Marvin, 2016; Everstine et al., 2013; Moore et al., 2012). Based on these databases, some scholars have tried to analyze the characteristics of FF/EMA and predict the expected food fraud type with notifications available (e.g., Everstine et al., 2013). Certainly, these studies have advanced our understanding of FF/EMA. However, only a limited number of cases were actually notified and documented in these databases (Bouzembrak & Marvin, 2016), suggesting further research is needed to better understand the extent of FF/EMA in countries around the world.

Though FF/EMA has long existed in human society (Spink & Moyer, 2011), today the increasingly prolonged and intricate food supply chain, often with mixed ingredients in processed foods, may create an environment in which fraudulent activities are easier to hide but difficult to detect (Everstine et al., 2013; Moore et al., 2012), resulting in new emergence of FF/EMA. This is especially true in China. For more than three decades, China has been experiencing rapid industrialization and urbanization, causing tremendous changes to its food supply chain. In 1978, the beginning of China's economic reform, more than 82% of the country's population lived in rural areas (Chinese Statistical Yearbook, 2015), and thus, China was largely an agricultural society. People consumed mostly raw, homemade, and less processed foods. Nevertheless, for the last three decades, as industrialization and urbanization accelerates, the proportion of the rural population has reduced to 45.23% (Chinese Statistical Yearbook, 2015). Modernization of China's food industry has resulted in increasing animal food production and growing capacity of food processing. People

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now consume much more processed and packaged foods, and often away from home (Liu, Wahl, Seale, & Bai, 2015; Waldron, Brown, & Longworth, 2010; Zhai et al., 2014; Zhang, Wu, Yao, Bai, & Xiong, 2014; Zhou, Zhang, & Xu, 2012). The fast transformation of China's food industry with massive food processing may increase the possibility for opportunistic behavior in food practices, resulting in emergence of FF/EMA in the country. In fact, the world's attention that has been given to FF/EMA is largely due to the uncovering of several high profile cases occurred inside China, for example, the 2008 *melamine*-contamination of baby milk powder causing six deaths and tenth of thousands of illnesses, the 2005 illegal use of carcinogenic red dye *Sudan Red I* in chicken products, and the 2009 illegal use of *clenbuterol hydrochloride* in animal feed also causing many foodborne illnesses (Everstine et al., 2013; Jia & Jukes, 2013). To our knowledge, fraudulent activities in food practice in the country were found in many circumstances. Nevertheless, detailed analysis of FF/EMA in China has limited to a few high profile cases. Given the sheer size and ever changing food supply chain of the country, an aggregated analysis of FF/EMA in China can be important not only for Chinese consumers' food safety and protection, but also for consumers in the rest of the world. Therefore, the objective of this study is to provide a comprehensive analysis on FF/EMA in China. Based on 1,553 media reports, we have attempted to characterize the fraud type, implicated foods and locations, as well as the adulterants, contaminants and abnormal conditions identified in these reported incidents as described below.

2. Materials and methods

2.1. The source of data

Learning about food safety problems is a perplexing task because of the intricate nature of food safety incidents, in which, many food items, contaminants, sources, and environments are concerned. Generally, people pay more attention to food incidents involved with acute foodborne illnesses to which immediate medical attention is usually required. In China, mandatory reporting on severe cases by medical staff or further professional investigation by Chinese Center for Disease Control and Prevention can be filed to the government or published in academic journals (Xue & Zhang, 2013). However, underreporting of foodborne illnesses is common, especially when the adverse health effects are chronic or with minor symptoms (Soon, Singn, & Baines, 2011). This is particularly true in the case of food fraud or adulteration in which deliberate acts are designed to evade detection (Everstine et al., 2013). Consequentially, professional or academic reports may not include most incidents of food fraud and adulteration. Literature suggests that many food safety concerns and scandals in China were initially uncovered by the media reports rather than official surveillance (Peng, Li, Xia, Qi, & Li, 2015). Therefore, for FF/EMA, we consider Chinese media coverage as our data source. Our analysis is based on media reports of food scandals that occurred in Chinese mainland and Hong Kong (a special district nearby Shenzhen, Guangdong province) for the period of 2004–2014. A total of 2,534 reports on food safety related problems were manually scanned. After excluding those repetitive or cross-published coverage and reports on incidents caused by human negligence, a total of 1553 reports on intentional food fraud and adulteration are used for our analysis. Detailed information about the source of our data is outlined in Table 1.

2.2. Method and the classification of FF/EMA

Based on these reported incidents or scandals, we conducted a systematic review. Our interest primarily lies in the following categories of information: regional distribution of recorded cases, food fraud type, food items involved, adulterants, contaminants or abnormal conditions involved, and implicated food source or locations. Since information on most of the categories is straightforward, we simply extract it for our analysis. For identifying food fraud type, to our best knowledge, there are several classifications available, including the USP food fraud database (Moore et al., 2012; USP, 2014), the EMA food fraud database (EMA, 2014), and the RASFF database (Bouzembrak & Marvin, 2016). The USP food fraud database has named 3 types of food fraud: *replacement*, *addition, and removal*; the RASFF database has listed 6 types of food fraud: *HC* (Improper, fraudulent, missing or absent health certificate), *illegal importation*, *tampering*, *CED* (Improper, expired, fraudulent or missing common entry document), *Expiration date*, and *Mislabeling*; and the EMA has classified 8 types of FF/EMA: *Intentional distribution of contaminated products, artificial enhancement, counterfeit, substitution, mislabeling, dilution, transshipment/origin masking, and theft and resale*. So far, there is no clear classification of FF/EMA by any Chinese source yet. Since the EMA database has defined the most types of FF/EMA and is inclusive of other classifications, this study uses it to categorize food fraud types for the reported cases in China. The description of food fraud type in the EMA database is listed in Table 2.

3. Results and discussion

3.1. Regional distribution of reported FF/EMA

Our result shows that a total of 1553 media reports of food scandals or incidents were actually all about economically motivated food fraud or adulteration. They occurred in 32 provinces or special districts in Mainland China and Hong Kong. The regional distribution of these cases is illustrated in Fig. 1, from which, one can see great regional variations for the reported cases. Regions like Guangdong, Beijing, Shandong, Zhejiang, Jiangsu had the highest numbers respectively, but places like Xinjiang, Qinghai, Ningxia, Inner Mongolia, and Yunnan had the lowest numbers correspondingly. It indicates a trend: regions with higher level of industrialization and urbanization had much higher number of cases, but less developed areas had the least number of cases in food fraud and adulteration.

3.2. Number of reported cases per type of FF/EMA

As mentioned in Section 2.2, we characterize food fraud types according to the EMA food fraud database. For those eight food fraud types described by the database (see Table 2), we have identified seven of them from the reported cases in our dataset and the number of cases for each type of food fraud or adulteration was accounted and listed in Table 3. While "artificial enhancement," "counterfeit," "substitution" and "dilution" mostly occurred in the procedure of food processing, "intentional distribution of contaminated products" and "mislabeling" was often involved in illegal food businesses. This can be further confirmed by the information in Table 5 (adulterants, contaminants or abnormal conditions) in Section 3.4 and Table 6 (implicated food source or location) in Section 3.5.

3.3. Foods involved in FF/EMA

In addition to identifying food fraud types, learning about the types of foods involved can be helpful to understanding the nature of fraudulent activities. Food items involved in fraud and adulteration are outlined in Table 4. Because some of these 1553 cases have

Table 1
Sources of data.

Name of media	# of reports used	Name of media	# of reports used
Southeast Express	10	Peninsula City News	18
Liaoshen Evening News	10	Beijing Morning Post	18
39 Health Network	10	Beijing Evening News	19
Oriental Morning Post	11	ChuTianMetropolis Daily	20
China business	11	Yangtse Evening Post	23
West China Metropolis Daily	11	Eastday	24
Jingchu Network	11	Legal Daily	25
National Business Daily	11	Yangcheng Evening News	25
Sanxiang City Express	12	Nanfang daily	29
CCTV	12	Chongqing Evening News	30
West network	12	Qilu Evening News	31
Xinmin Evening News	13	Beijing News	41
Changsha Evening paper	13	Guangzhou Daily	43
Bandao Network	13	New Express	43
The Evening News	14	People's Daily Online	45
Chinese Radio Network	14	China News Net	50
China 's economic networks	17	Beijing Times	53
ChinaNet	17	Xinhua Net	63
Southern Metropolis Daily	18	Other local media	713
Total			1,553

Table 2
Description of food fraud type in EMA database.

Fraud type	Description
Intentional distribution of contaminated products	Product was sold despite of foodborne contamination.
Artificial enhancement	The addition of an unapproved chemical additives to artificially enhance the quality or the other attribute of a product.
Counterfeit	Fraudulent labeling of a product by an unauthorized party as a brand name product
Substitution	Complete replacement of a food product/ingredient with an alternate food product/ingredient.
Mislabeling	Intentional misrepresentation with respect to quality, harvesting or processing techniques.
Dilution	Partial replacement of an alternate food product/ingredient to an authentic food product/ingredient to increase the overall weight or volume.
Transshipment/origin masking	Misrepresentation of the geographic origin of a product through false declaration of customs documents of mislabeling at retail.
Theft and Resale	Theft of a food product and resale into commerce through unapproved channels.
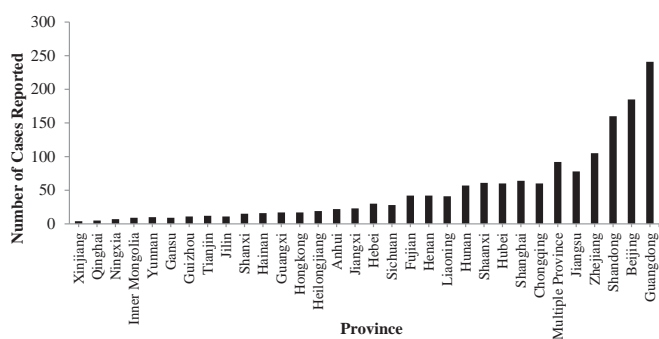
Fig. 1. Regional distribution of reported FF/EMA.

more than one food items involved with fraudulent activities, we have a total of 1567 food items accounted in Table 4. These numbers indicate that animal foods, further processed foods or mixed foods, drinks and beverages, as well as cooking oils are prone to fraudulent activities.

3.4. Adulterants, contaminants or abnormal conditions involved

Another category of information that can be critically important to comprehending the means used by and the motivations of the violators in food fraud or adulteration is the adulterants, contaminants or abnormal conditions involved. Because learning about the food adulterants, contaminants or abnormal conditions can be also

Table 3
Number of cases reported per type of food fraud.

Fraud types	Numbers of cases involved	Percentage (%)
Intentional distribution of contaminated products	482	31.04
Artificial enhancement	473	30.46
Counterfeit	276	17.77
Substitution	163	10.50
Mislabeling	110	7.08
Dilution	43	2.77
Transshipment/origin masking	6	0.39
Total	1,553	100.00

Source: author's calculation.

Table 4
Food items involved in fraud and adulteration.

Foods involved	Number of food items involved	Percentage (%)
Animal Foods	592	37.78
Dairy products	123	7.85
Sea foods	109	6.96
Pork	88	5.62
Animal organ & sausages	68	4.34
Poultry	53	3.38
Meat(mixed)	53	3.38
Beef	32	2.04
Animal blood	24	1.53
Lamb	21	1.34
Eggs	21	1.34
Grain-based foods	355	22.65
Desserts & Snacks	115	7.34
Rice	64	4.08
Soy-foods	60	3.83
Noodles	36	2.30
Steamed stuffed buns & dumplings	22	1.40
Steamed bread	15	0.96
You-tiao	8	0.51
Other grain-based foods	35	2.23
Drink/beverage	200	12.76
Alcoholic beverage	73	4.66
Water	48	3.06
Fruit juice	30	1.91
Tea	25	1.60
Soft drinks	24	1.53
Condiments & spices	85	5.42
Cooking oils	72	4.59
Fruits	62	3.96
Vegetables	58	3.70
Medicines	43	2.74
Nuts & seeds	32	2.04
Sugar & Sweets	19	1.21
Other foods	49	3.12
Hot pot (mixed)	19	1.21
Mushroom	13	0.83
Bee product	9	0.57
Soups	5	0.32
Canned food	3	0.19
Total	1,567	100.00

Source: author's calculation.

Table 5
Adulterants, contaminants or abnormal conditions involved in FF/EMA.

Adulterants/contaminants/conditions	Numbers of adulterants/contaminant/condition	Percentage (%)
Forbidden additives	373	23.23
Food additives	203	12.64
Foreign substances	180	11.21
Counterfeit foods	179	11.14
Common counterfeit foods	115	7.16
Counterfeit alcohol	46	2.86
Counterfeit bottled water	18	1.12
Recycled or discarded foods	166	10.34
Discarded meat	102	6.35
Recycled oil	64	3.99
Expired or perished foods	109	6.79
Other chemicals/industrial substitutes	108	6.72
Microorganism	101	6.29
Bacteria	72	4.48
Fungi	25	1.56
Virus	4	0.25
Pesticides	38	2.37
Medicine	36	2.25
Animal medicine	20	1.25
Human medicine	16	1.00
Natural toxins	34	2.12
Plant hormones	23	1.43
Other abnormal conditions	56	3.49
Total	1,606	100.00

Source: author's calculation.

Table 6
Implicated food source or location.

Food source	Number of concerns	Percentage (%)
Illegal food shop	399	25.69
Food company/Processor	397	25.56
Supermarket/Grocery	191	12.30
Restaurant/cafeteria	113	7.28
Farmers' market	96	6.18
Food wholesaler	57	3.67
Street vender	55	3.54
Food importer	52	3.35
Farm	51	3.28
Small food store	48	3.09
Fast food service	29	1.87
Pharmaceutical company	19	1.22
Slaughter house	9	0.58
Online	3	0.19
Other locations	34	2.19
Total	1,553	100.00

Source: author's calculation.

helpful to understanding the patterns of fraudulent activities and their adverse health effects, information regarding them could be valuable to both food safety inspection and the diagnosis and treatment of foodborne illnesses if applicable. In Table 5, we outlined the adulterants, contaminants or abnormal conditions involved in these 1553 cases. Because some of the cases involve multiple adulterants, contaminants or abnormal conditions, we have a total of 1606 items accounted. Also, what we should clarify here is the words "adulterants", "contaminants" and "abnormal conditions" used in the table. For many cases in our dataset, chemical, biological or physical substances were clearly identified as either "adulterants" or "contaminants", such as additives, microorganisms, and other physical matters; however, for many other cases, fraudulent activities involve abnormal conditions, such as counterfeit foods, recycled or discarded foods (e.g., discarded animal meats or organs), and expired foods or perished foods and so on, without mentioning of any substances. Hence, we account the former as "adulterant" or "contaminant" and the latter as "abnormal condition." Different categories of adulterants, contaminants and abnormal conditions are listed in Table 5 according to their frequency of occurrence in a descending order. The statistics used in the following discussions in this section can be found in the Table.

3.4.1. Adulterants involved

Our data reveals that a total of 35.87% of the adulterants, contaminants and abnormal conditions involve "additives", including the use of forbidden additives (23.23%) and inappropriate use of legally allowed food additives (12.64%). For forbidden additives, the following substances have been found and reported (in a descending order according to frequency appeared in the incidents): *formaldehyde*, *nitrite*, *melamine*, *sodium formaldehyde sulfoxylate*, *alum*, *beef extract*, *clenbuterol*, *sulfur dioxide*, *Sudan red*, *diethylhexyl phthalate* (*DEHP*), *fluorescent bleacher*, *talcum powder*, and so on. Some of these substances, such as *nitrite*, were historically used for food preservatives (Binkerd & Kolari, 1975). However, these additives are all banned for use now because they have serious adverse health effects. For instance, *formaldehyde* is considered a carcinogen (Tang et al., 2009), and *sodium formaldehyde sulfoxylate* may have similar health effect. *Nitrite* not only is considered a co-carcinogen (Schweinsberg & Bürkle, 1985), but also was responsible for many deaths and acute foodborne illnesses due to its inappropriate use as a food additive (Liu, Tang, Liu, & Yin, 2008; Xue & Zhang, 2013). Other forbidden additives mentioned above may also have similar adverse health effects. Detailed

information from our data suggests that the purposes of using these substances as adulterants were either to replace legally allowed additives to save costs (e.g., *formaldehyde, nitrite and DEHP*), to change color, appearance, or texture of foods (e.g., the uses of *sulfur dioxide*, *Sudan red*, *fluorescent bleacher*, *DEHP*, *alum*, *talcum powder*), or to keep counterfeit foods or adulteration from detection (e.g., the uses of *melamine* and *beef extract*).

In China, the current food safety regulation (GB-2076-2014) allows about 2,300 food additives (a number less than 1/6 of the world's highest) to be used in food processing (Jia, 2015). However, some uses of these legally allowed additives violate the regulatory codes, including overuse (the quantity of some additives used exceeds their legally specified amount) and novel use of them (new use of these food additives is not the legally specified use). The main purpose of using these additives was to fake foods. For instance, using too much thickening or gelling agents in dairy products, making fake steamed multi-grain bread by adding edible pigment in wheat flour, using certain combinations of edible food additives to fake orange juice, and so on. Although the adverse health effects of using legally allowed food additives are not all clear, some recent studies have not only shown the linkage between the use of food additives and hyperactivity behaviors in children (e.g., McCann et al., 2007), but also confirmed that food additives are more hazardous if used in combination (Mercola, 2015; Park et al., 2009).

From above discussion, one can see that additives, no matter forbidden or legally allowed, were heavily involved in food fraud and adulteration, especially for four types of food fraud:"artificial enhancement," "counterfeit," "substitution," and "dilution."

3.4.2. Foreign-substances involved

From Table 5, we can see that 11.21% of the total counts of adulterants, contaminants and abnormal conditions were foreign substances in foods. Our detailed information indicates these substances include insects, metals, plastics, rubbers, glass, feathers, cigarette ends, and so on. This suggests that food processing and handling in certain food businesses did not follow the regulatory procedures or hygienic standards. It is consistent with the data in Table 6 that more than 1/4 of the food locations recorded in our data were actually not legally registered and inspected. Apparently, avoiding the costs of regulatory requirement and food safety inspection was the main reason for these illegal food businesses. Detailed information suggests this kind of contaminants was involved in either "intentional distribution of contaminated products" or "dilution" (according to the intention and amount of substance involved).

3.4.3. Counterfeit foods

Our data tells that 11.14% out of 1606 counts on adulterants, contaminants and abnormal conditions were counterfeit foods, including common counterfeit foods (7.16%), counterfeit alcohol (2.86%), and counterfeit bottled water (1.12%). Detailed information of data shows that many common foods, such as beef and mutton were counterfeited with other type of meats; sesame paste was faked using corn ingredient; and *tofu* was made from other grain ingredients instead of soybean. Alcohol beverages were another major category of foods frequently faked in China, including white sprit (*bai-jiu*), wine, and beer. Generally famous brands were faked using a blend of low-grade ones. Also, our data indicates that bottled water was faked using tap water. We classify this category of foods as "counterfeit" for fraud type in Table 3 in Section 3.2.

3.4.4. Recycled or discarded foods

Generally, recycled or discarded foods contain adulterants or contaminants, such as adulterant-substances and microorganisms.

Nevertheless, the focus of the media reports on this category of foods was mainly on their condition or status but not on these adulterants or contaminants. Therefore, we classify "recycled or discarded foods" as abnormal conditions of foods. As Table 5 shows, recycled or discarded foods constitute for 10.34% of these 1,606 adulterants, contaminants and abnormal conditions recorded in our data, including 6.35% for discarded meats (e.g., meats from ill or dead animals, and poisonous animal organs like thyroid) and 3.99% for salvaged or recycled oils. Detailed information in some of the reports suggests that selling these foods had been an illegal business in certain areas. This is an indication of weak legal enforcement of food regulations and laws especially in the handling of animal foods and cooking oil supply chains. We consider food malpractice with this sort of abnormal condition as either "intentional distribution of contaminated products," "mislabeling" or "dilution" according to the nature of the fraudulent activities in each case.

3.4.5. Other chemicals or industrial substances

Other chemicals or industrial substances account for 6.72% out of these 1606 adulterants, contaminants and abnormal conditions. They include heavy metals (e.g., *mercury, lead, chromium, arsenic, and aluminum*) found in vegetables, *pulverized lime* used for drying foods, industrial rosin used to remove animal hair, and even cement used to increase the weight of foods. These adulterants or contaminants are largely related to illegal food shops with unregulated food processing and illegal selling of foods. This too indicates large legal gap and weak enforcement of food safety regulations in certain areas in the country. We consider food malpractices with this kind of adulterants or contaminants as "artificial enhancement,""dilution" or "intentional distribution of contaminated products" for fraud types according to the nature that these substances were involved.

3.4.6. Microorganisms

A total of 6.29% of the counts on food adulterants, contaminants or abnormal conditions are microorganisms, including bacteria for 4.48%, fungi for 1.56%, and viruses for 0.25%. Bactria found in our data were mainly *E. coli, V. parahemolyticus, and staphylococcus aureus*. Fungi were mostly *aspergillusflavus*. In addition, a few cases of *porcine reproductive and respiratory syndrome virus (PRRSV)* and *H1N1 virus* were also involved. Traditionally, microorganisms were responsible for many acute foodborne illnesses and deaths in China, and human negligence or unawareness was the major cause of food contamination (Xue & Zhang, 2013). However, the microorganisms listed in this study were mainly involved in fraudulent activities categorized as "intentional distribution of contaminated products."

3.4.7. Expired or perished foods

We consider the expired or perished foods as another type of abnormal condition. In our recorded data, they account for 6.79% of these 1606 adulterants, contaminants and abnormal conditions involved in FF/EMA. This does not include above-mentioned recycled and discarded foods that were illegally reused or sold. It also suggests that legal standards of foods or food protocols were not followed by some food businesses due to intention to avoid losses. This type of food condition was mostly involved in food fraud type, "intentional distribution of contaminated products," or "mislabeling."

3.4.8. Pesticide, medicine, natural toxins or drugs, and plant hormone

Our data indicates that out of these 1,606 counts of adulterants, contaminants and abnormal conditions, *pesticide, medicine, natural toxins or drugs*, and *plant hormone* accounts for 2.37%, 2.25%, 2.12%,

and 1.43% respectively. By looking at the names of these substances, one may understand the common application of them immediately. However, the use of them in FF/EMA can be novel and thus deserves our attention. For example, *pesticides*, as we all know, are usually used for crop protection, but in some cases of FF/EMA, they were used to preserve foods (e.g., pesticides were used to preserve vegetables and fruits). *Medicines*, such as *luteosterone, ractopamine*, and *reserpinum* were used to increase food production (e.g., milk, chicken, and other meats) other than their original utilization; and *methenamine*, an old medicine, was used to increase the production of dried bean curd stick (*fu-zhu*). Natural toxins can be produced if certain plant foods are not preserved appropriately. For instance, in some cases of this study, *solanine* from potatoes was causing foodborne illnesses because of intentional selling of potatoes with foodborne toxin. Detailed information of our data reveals that *drugs* like *poppy seeds and plant* were used in the food *hotpot* (*huo-guo*) in order to enhance the taste of food and make consumers addicted to the food. Our data also shows that plant hormone was used to increase the yields or shorten the production life of certain plant foods, such as tomatoes, cucumbers, bean sprouts, watermelon, kiwifruit, and so on. Food malpractices with this type of substance are considered "artificial enhancement," "intentional distribution of contaminated products."

3.4.9. Other abnormal food conditions

In addition to selling of counterfeit, recycled, discarded, expired or perished foods, there were also other abnormal food conditions, accounted for 3.49% of these 1553 cases of FF/EMA recorded in our data. Majority of this type of abnormal conditions include fresh meats (e.g., beef, lamb, and pork) sold with intentionally injected water. Some other cases were GM foods sold as non-GM foods. These cases have been accounted either as "dilution" or "mislabeling" in Table 3 in Section 3.2.

3.5. Concerned food sources or locations

Tracing where the concerned foods came from could have important implications for effective enforcement of food safety law and consumer protection. For these 1553 cases of FF/EMA, we outlined the concerned food sources or location in Table 6. The simple statistics here suggest that fraudulent activities mostly occurred in locations where foods were more processed, mixed, and consumed away from home and in places where regulatory loopholes existed. Although food wholesalers account for only 3.67% of the sources for food frauds, they deserve more attention because the volume of implicated wholesale foods can be huge, and contaminated foods can potentially reach a large number of customers in a single incident.

4. Conclusions and policy implications

This study concludes that economically motivated food fraud and adulteration is indeed an emerging and serious food safety issue in China. Our aggregated and systematic analyses of these 1,553 cases of FF/EMA may have the following policy implications.

First, with an aggregated review from different perspectives, this study can be helpful to food safety risk assessment and prioritizing the target areas for food safety regulation and enforcement. Second, our data and analysis may provide useful information for building FF/EMA database in China. Third, the results of this study can be used for food safety risk communication and management in the case of FF/EMA. Moreover, our study suggests that not only legal means but also moral leadership is needed to building sustainable and healthy food practices in China.

Acknowledgements

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SCIENTIFIC REPORTS

Integration and Typologies of Vulnerability to Climate Change: A Case Study from Australian Wheat Sheep Zones

Jianjun Huai

Although the integrated indicator methods have become popular for assessing vulnerability to climate change, their proliferation has introduced a confusing array of scales and indicators that cause a science-policy gap. I argue for a clear adaptation pathway in an "integrative typology" of regional vulnerability that matches appropriate scales, optimal measurements and adaptive strategies in a six-dimensional and multi-level analysis framework of integration and typology inspired by the "5W1H" questions: "Who is concerned about how to adapt to the vulnerability of what to what in some place (where) at some time (when)?" Using the case of the vulnerability of wheat, barley and oats to drought in Australian wheat sheep zones during 1978–1999, I answer the "5W1H" questions through establishing the "six typologies" framework. I then optimize the measurement of vulnerability through contrasting twelve kinds of vulnerability scores with the divergence of crops yields from their regional mean. Through identifying the socioeconomic constraints, I propose seven generic types of crop-drought vulnerability and local adaptive strategy. Our results illustrate that the process of assessing vulnerability and selecting adaptations can be enhanced using a combination of integration, optimization and typology, which emphasize dynamic transitions and transformations between integration and typology.

Climate change can have a huge impact on socioeconomic and ecological systems[1]. Through recent decades, interdisciplinary research has contributed to improving our knowledge of empirical methodologies related to assessing climate change vulnerability[2–4]. In recent years, integrated indicators combining climatic and non-climatic elements at different scales have been developed for quantifying vulnerability[5]. These aim to develop robust and credible measures incorporating diverse methods such as principal components analysis (PCA)[6] and draw on research into adaptive mechanisms[7]. For example, vulnerability is considered to be a function of exposure, sensitivity and adaptive capability[8] or it can be calculated by different formulations in different contexts[9,10].

However, the current generation of integrated methods and diverse calculation techniques can lead to confusion in selecting scales, indicators and calculation methods. Existing integrated indicator methods such as integrated assessment (IA) and 'Drivers-Pressure-State-Impact-Response' (DPSIR)[11] are not well suited for combining multiple spatial, temporal scales and socioeconomic-ecological dimensions in a locality due to limited knowledge of several factors, such as the availability of a farm's perceived adaptations. This has led some scholars to question what indicators can accomplish in the domain of climate change vulnerability[12] because some indicators represent neither what researchers want to measure nor allow for the effect of feed-back[13]. These integrated indices also ignore the interactional effects of complementarities and substitution between indicators in PCA, which can misinform stakeholders such as farmers[14,15] and result in a science-policy gap[16]. Uncertainties combine with different methodologies and diverse place and time scales, due to the different contexts. Local socioeconomic conditions and wider ecological environments vary widely. Much of the relevant measurement and methodology for understanding vulnerability and adaptation to climate change can therefore only be appreciated in a particular context.

A typology can help to identify specific types of vulnerability, adaptations, mitigation and stakeholders, to generate a general framework for understanding interactions between environmental stress and human activities[17].

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For instance, typologies of crop-drought vulnerability distinguish between resilient and sensitive cases and their different adaptations according to their dissimilar socioeconomic conditions[18]. Also, local income, household size and climate give rise to a spatial typology of human settlement in research that rejects a one-size-fits-all adaptive decision in England[19]. Typologies have been used to appreciate environmental heterogeneity, assess overarching adaptive activities, analyze the cost of climatic adaptation and mitigation; and to consider the needs of all types of primary producers[20–22].

In order to reflect heterogeneity on different dimensions, constructing a typology involves a series of questions. It is important to identify the special conditions of local climates at different scales[23], the regional limits of adaptive capacity[24] and to consider the interests of stakeholders[25]. The monthly growing response of vegetation to drought in some regions is selected to provide some useful information concerning the operations of the time scales[26]. Under the framework of "Loss-response", the time dimension includes before, during and after disaster periods, the spatial dimension contains community, town, country and province, while there are also economic, institutional, social, and environmental attributes[27]. A typology comprised of six content themes: *study region, climate hazards, relevant sector, impacts of concern, potential adaptation options, decision processes and tools for adaptation*[7]. The assessment of vulnerability should answer the "4W2H" questions: *What are the goals? How is the assessment of vulnerability framed? What are the technical methods? Who participates in the assessment? How will it be used to facilitate change?*[28] Thereby a typology can identify different types of temporal and spatial scales, attribution, research objectives, adaptations, methods of measurement and policy tools. Nevertheless, few researchers to date have systematically described the process of decision-making in climate change adaptation and none has clarified the relationships between typology and integration or emphasized the match and optimization of indicators.

In the paper, I test the hypothesis that the process of assessing vulnerability and selecting adaptations can be enhanced by using a combination of integration, optimization and typology. I apply a top-down method to develop a six-dimensional analysis framework that considers location, time, people, focus, method and adaptation to answer the "5W1H" questions: "*Who (some people) are concerned about how to adapt to the vulnerability of what to what in some place (where) at some time (when)?*" It includes the following, more specific questions:

(1) *Where does climate change occur? (Where)*
(2) *When are people affected by climate change? (When)*
(3) *Who is concerned about climate change? (Who)*
(4) *Which systems are affected by climate change? (Of What)*
(5) *Which kinds of climate change occur? (To What)*
(6) *How will the people assess and adapt to climate change? (How)*

The paper explores an integrative understanding of vulnerability and adaptation pathways through integrating socioeconomic indicators into the measurement of vulnerability, comparing different ways of calculating vulnerability, classifying resilient and sensitive cases and constructing a typology of adaptation in a defined system based on empirical data. Drought data was obtained from recent research[29] while the rest of the data comes from the Australian Agricultural and Grazing Industries Survey (AAGIS).

I develop a systematic method for integrating data at appropriate scales, optimizing the calculation of vulnerability and constructing a typology of adaptations. I contribute to the literature on integration, optimization and typology of vulnerability and adaptation using the case of Australian crop-drought vulnerability. Specially, our novelties are (1) a six-level analysis framework for transforming typology to integration, (2) a detailed seven-fold typology of vulnerability and adaptive strategies for Australian crops, (3) and a dynamic transition method for transformations between integration and typology.

Six-dimensional analytical framework

In a defined system, *who* (some people) would be concerned about *how* to adapt to the vulnerability of *what* to *what* in some place (*where*) at some time (*when*)? To answer the "5W1H" questions, the analysis framework of vulnerability should contain six typologies of space, time, stakeholders, focus, method, and adaptation (Fig. 1).

The first three steps of systematically defining environments are: ascertaining the types of purposes which are significant for stakeholders, identifying location types to define the study areas at appropriate spatial scales and selecting the time scale of the research. Careful selection of areas to investigate according to spatial heterogeneity in socioeconomic and ecological systems can answer the question "*Where does climate change occur?*" A typology of locations means that the researcher can locate an appropriate spatial scale to assess vulnerability at global, national, regional and community levels through scientific methods. Climate change has different characteristics and influences during different time-periods, therefore it is important to answer the question "*when are the people affected by climate change?*" A time typology implies that the researcher should find the effective temporal scale from millennia, centuries, decades and years, according to the frequency and severity of climate shocks. Due to the heterogeneity of regions, different groups of people have dissimilar responses to climate change[30]. For example, farmers who have experienced a severe drought will be more concerned about climate change in the future than those who have never known drought conditions. A typology of purposes makes it possible to identify "*who is concerned about climate change?*" based on their different experiences of it. In general, climate change at different spatial and temporal scales affects people in diverse ways, so I need to select appropriate typologies to define all relevant systems.

The next three steps include identifying what I call "focus types" to measure the sensitivity "of what", selecting the types of method to assess the level of exposure to climate shocks and finding types of adaptation to reduce the vulnerability at practical dimensions. Within a defined system, many kinds of climatic stocks, such as droughts, floods, freezing conditions and hail storms, etc. may happen simultaneously and affect various kinds of activity.

2
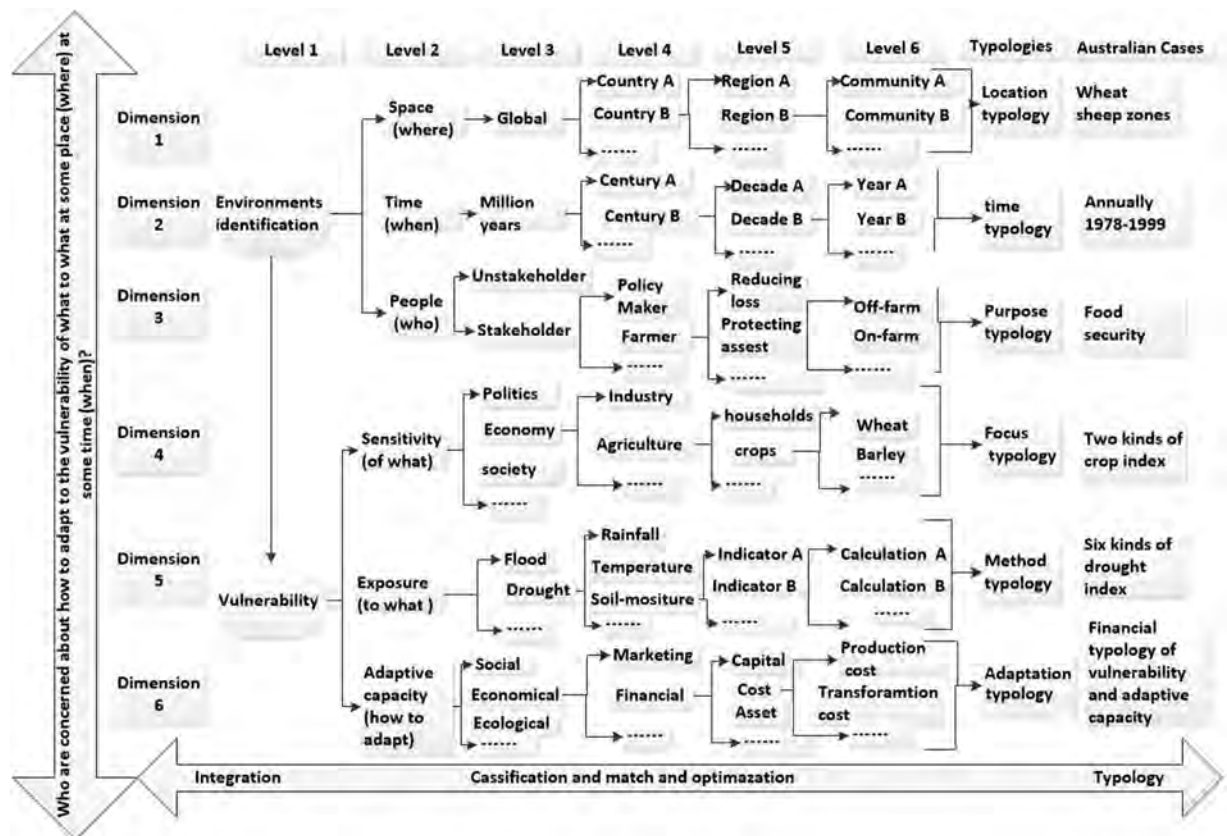
Figure 1. Classifying vulnerability is addressed by answering the "5W1H" questions: Who (some people) are concerned about how to adapt to the vulnerability of what to what at some place (where) at some time (when)?

The focus type shows paths for exploration to select "of what to what" to answer "*which kinds of climate change occur?*"and "*which systems are affected by climate change?*" This may consider the vulnerability of crops to drought, the vulnerability of rural livelihoods to water scarcity etc. The "method typology" provides the processes needed to measure vulnerability, such as conceptualizing and calculating crop-drought vulnerability. The question of "*how will people assess and adapt to climate change?*" involves assessing vulnerability and selecting effective adaptations. The "adaptation typology" can provide a useful tool to assess local adaptive capacity and to select local adaptations according to regional system constraints.

The "six typologies" framework describes how to answer to the "5W1H" questions in principle. How it operates in practice can be better understood when I translate this framework into a practical methodology and apply it in a case study in Australia.

Methodology: detailed application of the framework in Australia
Defining the study space, time and people to answer the "where", "when" and "who" questions.
Identifying a typology of locations to answer the "Where" question. Australia is the world's sixth largest exporter of aggregated food production and thus contributes significantly to world food supply. Among many broad acre agricultural production systems in Australia, wheat sheep zones are found to account for 90–95% of Australia's crop outputs, but often suffer from long-term droughts[31,32]. Therefore, I select 12 wheat sheep zones as our study areas, after continually shrinking the spatial scales from country to regions, then to the main crop production regions of Australia. The wheat sheep zones cover the north and east Wheat Belt (522), the central and south wheat belt (521) in Western Australia, the Eyre Peninsula (421), the Murray Lands and Yorke Peninsula (422) in South Australia, the Mallee (221), the Willera (222), the Central North (223) in Victoria, the Riverina (123), the Central West (122), the North west Slopes and Plains (121) in New South Wales, the Eastern Darling Downs (321) and the Darling Downs and Central Highlands in Queensland (the number in the parentheses represents the region code).

Discovering a time typology to answer the "When" question. I select an annual scale rather than a monthly or seasonal one because I can then use the annual socioeconomic indicators and the crops grow to harvest once a year. I select 1978–1999 as our observed period because recent literature has analyzed the vulnerability of crops to drought during recent decades but before 2000 there had been little attempt to integrate socioeconomic indicators into climate change research in Australia[28,33].

Identifying a typology of purpose to answer the "Who" question. Many related groups of people, such as local policy-makers, scientists and farmers, etc. emerge as being relevant for research into the impact of climate change. During 1978–1999, since climate change, such as drought directly affects agricultural systems including crops and farmers, and results in huge losses of crop harvests, farmers are concerned about the vulnerability of crops. However, local policy-makers and scientists have little response to the influence of Australia's drought on socio-economic variations[34]. Australian farmers are most affected directly by climate change and are most concerned about its adverse impact. Therefore, I focus on the farmers as the most directly affected people.

Measuring exposure, sensitivity and vulnerability to answer the "of what", "to what" and "how to adapt" questions.

Discovering "focus types" to answer the "of what" questions. The focuses types result from the process of selecting the sensitivity of something from everything according to particular conditions. Sensitivity reflects the response of a given system to climatic variation, may be influenced by socioeconomic and ecological conditions[35]. Practically everything is affected by the climate in the research fields, I am considering so that I hardly need to list and select which is their first priority. In Australian wheat sheep zones during 1978–1999, crop yields were directly affected and different crops respond differently to climatic variations[36]. Therefore, I applied the crop yield anomaly of wheat, oats and barley as a proxy for crop sensitivity to drought.

The selection of appropriate indicators and methods of calculation are key components in the empirical analysis. The "method types" include such selections and comparisons between different methods. Many researchers have used the detrended yield to assess the crop vulnerability to climate change. For example, the modeling crop yield[37], or simulated yield at large scales can used to monitor or forecast regional variability in crop production[38]. To eliminate non-climatic effects on yields, the detrended yield was obtained by subtracting the trend yield from the actual yield[39]. The 21-year linear sliding average method was applied to remove trends in yields, while winter wheat yield was divided into trending yield and meteorological yield, which was further processed as the relative meteorological yield[40,41]. Following previous research[31,42–44], I use the detrended yield and averages of actual yield to measure crop sensitivity to drought. I detrended the annual crop yield via an auto-regression function with 3-year lags. Next, I calculated two Crop Failure Index (CFI) using the detrended yield ($\hat{Y}_{ry}$) and the average yield ($\overline{Y}_{ry}$), respectively, as in equation (1). A CFI of more than one indicates crop failure and the greater the CFI, the more severe is the crop failure.

$$CFI_{ry} = \begin{cases} \dfrac{\hat{Y}_{ry}}{Y_{ry}} - 1 \\ \dfrac{\overline{Y}_{ry}}{Y_{ry}} - 1 \end{cases}$$

(1)

Identifying "method types" to answer the "to what" questions. Drought is a major problem in Australia[45]; the Millennium droughts for example reduced aggregate agricultural production and exports which resulted in global fluctuations in food prices[46]. Recent droughts, especially in 2007, also caused significant destruction[47]. Exposure is the magnitude and frequency of extreme climate events[48], so I selected drought as an obvious exposure element of climate change according to the focus types.

According to the method types, the selected indicators of drought include rainfall, temperature and soil-moisture, etc. Due to its direct link with the planting of crops, I used soil-moisture to estimate the severity of drought. Then, I compared the results using different calculation methods of the drought index using soil-moisture data. Many agrohydrologists have researched the conceptual and practical issues of scales and scaling, for instance, why scaling problems arise, the define and types of scales and the key questions with regard to upscaling and downscaling were discussed[49]. The differences in the spatiotemporal patterns of temperature and precipitation are statistically significant, and the temporal trends and spatial structures of each meteorological element were not equally modified[50]. Examining habitat loss and habitat fragmentation across different time periods and at different spatial scales is essential for understanding their joint and individual effects on plant community composition[51]. Therefore, matches between spatial scales and time scales are critical in comparing different calculation methods, which include the transformation form one spatial scale to another and a lagged offset measure of time[52].

Comparing many different ways of performing the calculation of drought index, I selected six ways to express the drought index (DI) following the relevant literature that use at least three different calculation methods[18,53–56]. Firstly, the Soil Moisture Deciles-based Drought Index (SMDDI) of the Australian Bureau of Agricultural and Resource Economics and sciences Regions (ABARER) was used as the drought index. This is abbreviated to SNR from SMDDI in the Natural Resource Management Regions (NRMR)[29]. Map grids divide the Earth's surface into a uniform array and since there are different planted areas in each grid, I weighted the SMDDI in each geographical grid by the percentage of its planting area in the whole research area to produce a weighted SNR, WSNR. Here, following previous literature[29], I defined vulnerable cases to be those with a SNR or WSNR greater than 0.03. Secondly, I indirectly measured droughts using SNRM or WSNRM, which are defined as the ratio of the SNR or WSNR to its own mean. I ignored SNRM or WSNRM when it was zero because this simply indicates there was no drought. MSNR or MWSNR is the reciprocal of the SNRM or WSNRM, respectively and was used as a wetness index. Finally, I ascertained the appropriate research duration through comparing the correlations between these six types of drought index and annual yield as well as failure for three crops in the same and offset (lagged by one) year. All calculation methods are defined in equation (2):

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$$DI_{ry} = \begin{cases} SNR_{ry} = \sum_{i=1}^{n}\left(\dfrac{SMDDI}{m}\right)_i \\[2mm] WSNR_{ry} = \sum_{i=1}^{n} w_i \left(\dfrac{SMDDI}{m}\right)_i \\[2mm] SNRM_{ry} = \dfrac{SNR_{ry}}{\overline{SNR_r}} \\[2mm] WSNRM_{ry} = \dfrac{WSNR_{ry}}{\overline{WSNR_r}} \\[2mm] MSNR_{ry} = \dfrac{\overline{SNR_r}}{SNR_{ry}} \\[2mm] MWSNR_{ry} = \dfrac{\overline{WSNR_r}}{WSNR_{ry}} \end{cases}$$

(2)

where r indicates the type of region and y stands for the year, m is the number of grids in each NRMR, i is the number of grids and w is the weight or percentage of the grid in each ABARER.

Building the "adaptation type" to answer the "How" questions through classification, integrating, optimizing and typology. Sensitivity as "the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli"[57], while resilience refers to the magnitude of disturbance that can be absorbed before a system changes to a radically different state as well as the capacity to self-organize and the capacity for adaptation to emerging circumstances[58,59]. Thus, sensitivity and resilience have common elements of interest: the shocks and stresses experienced by the social-ecological system, the response of the system, and the capacity for adaptive action[3]. Given certain exposure, sensitivity maybe negative with resilience. Here, I only classify resilient and sensitive cases, which means the resilience equals to less sensitivity so that I can identify some vulnerable cases.

First is to classify resilient and sensitive cases according to the ranks of CFI and DI. The relationships between sensitivity and exposure determine that the method types should compare and integrate the CFI and DI into vulnerability at appropriate space and time scales. I classified the resilient and sensitive cases and the financial typology of vulnerability. After ranking the CFI and DI, I considered "resilient" cases if the CFI was below the median while the DI was above the median. "Sensitive" cases were defined to be those where the CFI was above the median and the DI was below the median.

Second is to integrate and optimize vulnerability. Although exposure and sensitivity are integrated into vulnerability through various calculations by different researchers, to simplify the question, I defined the crop-drought vulnerability index (VI) as sensitivity divided by exposure and then used the divergence of yield from its own mean (DY) as the baseline of vulnerability. Since DY reflects the variance of the actual yield loss relative to the average, different levels of VI represent the variance of relative crop yield loss to the variance of relative drought, thereby I selected the optimal crop-drought vulnerability index as the smallest ∂_j that is the difference between the VI and the DY[9,10].

$$VI_{ry} = \frac{CFI_{ry}}{DI_{ry}}$$

(3)

$$DY_{ry} = \frac{Y_{ry} - \overline{Y_r}}{\overline{Y_r}}$$

(4)

$$\partial_{ry} = (VI_{ry} - DY_{ry})$$

(5)

Selecting and integrating adaptive capacity is the third step. Adaptive capacity reflects the ability of a system to adjust to changing climate in a way that reduces potential damage and takes advantage of any associated opportunities[60]. The socioeconomic attribution of adaptive capacity determines various method types; the key operational measurements of adaptive capacity is about how to identify which indicators from all possible socioeconomic indicators using first-classifying-then-integrating methods. I investigated what parameters indicate a statistically significant difference between resilient and sensitive cases using 146 socio-economic indicators from the AAGIS. Then, I took the indicators from the 1st principal component (PC1) from a PCA of the selected indicators. I identified significant indicators through a Spearman's correlation test among the indicators included in *PC1* and levels of vulnerability for resilient and sensitive cases, respectively. Finally, I characterized regional adaptive capacity using the parameters of capital, cost, debt, receipts, farm equity, family farm, farm performance and other assets.

Providing typologies of vulnerability and adaptations based on regional financial constraints is the fourth step. The setting up of reasonable criteria is a critical step in defining the adaptation and vulnerability types. In systems affected by climate change, social heterogeneity for different stakeholders at particular locations and times are relevant for such criteria. Farmers in Australian wheat sheep zones, in the period 1978–1999, focus on their financial costs and benefits from climate change. To find financial constraints for every region, I summed all the significant indicators for each category. Total opening capital and debt presents one category; total receipts,
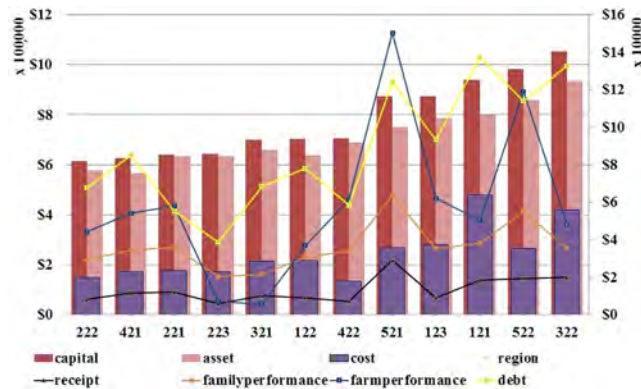
Figure 2. Different regions suffered from different capital constraints. The numbers under the horizontal axis represent region codes.

farm performance, family performance and assets are the sum of their indicators respectively. Total cost equals the sum of all cost indicators except expenditures on fodder, fertilizer and crop & pasture chemicals. Lack of capital, low receipts and assets, family farm and farm performance, as well as higher costs and debt are the regional constraints to adaption to climate change.

Results: effectiveness of the "six typologies"

Method typology through optimization can provide the optimal crop-drought vulnerability index. VI^{11} and VI^{12} demonstrated that our comparisons and optimizations in our methodology types are helpful in measuring vulnerability. For wheat, the smallest values of VI^{11} and VI^{12} become the optimal wheat-drought vulnerability indices in each region. Similarly, VI^{11} or VI^{12} for barley and oats are the optimal measurements.

A typology of locations is beneficial for identifying local financial constraints and the spatial typology of vulnerability. *Local financial constraints provide the criterion of a typology of locations.* Figure 2 shows how each region is limited by financial factors, which effectively reflect the suitable criterion to express local heterogeneity. For instance, Mallee (221) is a capital-constrained region, which is also limited by having fewer assets. North West Slopes and Plains (321) are limited by greater agricultural costs while lower farm receipts have a negative influence in Central West (122). Central North (223) is restricted by farm performance and family farm, while greater total debts occur in Central and South Wheat Belt (521).

The methodology type with regional heterogeneity successfully matches the typologies of regions and their constraints. Table 1 shows how the resilient and sensitive regions for different crops are affected by different financial conditions. The resilient and sensitive cases have diverse financial characteristics. The more sensitive regions tend to have less capital, crop receipts, cost, debt, agricultural assets, and family and farm performance. For either VI^{11} or VI^{12}, all influences significantly and negatively affect vulnerability. VI^{11} for wheat, barley and oats is affected mainly by costs and debts, while VI^{12} for wheat has additional influences including most of the indicators for capital, costs and debts.

Spatial typology of crop-drought vulnerability. Further, the methodology type also clearly shows the distributions in spatial typologies of vulnerability. In Fig. 3, the box plots illustrate the distribution of sensitive and resilient regions for wheat, barley and oats in the wheat sheep zones. The longer boxes indicate a higher sensitivity while the shorter boxes indicate more resilience. For instance, wheat is resilient to drought in the North and East Wheat Belt (522), whereas it is sensitive in the Central West area (122). North West Slopes and Plains (121) is one of the most resilient regions while Central West (223) is one of the most sensitive areas for barley. Similarly, the regions of high resilience for oats include North West Slopes and Plains (121), while sensitive regions for oats include Male (221), Central North (223), and Eyre Peninsula (421).

Time typology benefits the matching of one-year-lagged drought to crop yields. The time typology involves not only the selection of appropriate time scales, but also in finding an effective offset where appropriate. In Table 2, SNR and WSNR have a negative effect on crop yields and a positive effect on crop failure. All drought indices have significantly larger coefficients with actual crop yields and crop failures when lagged by one year compared to the same year. Therefore, I selected the drought index lagged by one year (1980–1998) as the dependent variable to investigate crop-drought vulnerability from 1981–1999.

A typology of purposes describes the interaction between policy options and research. Once I take into consideration financial constraints, the Australian main crop and the lagged-one-year effect of the drought on the crops, not only farmers, but also the policy-makers and agricultural scientists come to a better understanding of the impact of climate change on the crops. Scientists have better opportunities to assess crop-drought vulnerability and to make useful suggestions to the government and farmers, who consequently may gain more financial support from the local economy. When policy-makers are aware of the practical issues of farmers and the scientific assessments of researchers, they are in a better position to find solutions to mitigate and

| Categories (the first principal component) | VI[11] | | | | | | VI[12] | | | | | | Expected signs |
| | wheat | | barley | | oats | | wheat | | barley | | oats | | |
	R	S	R	S	R	S	R	S	R	S	R	S	
Capital													−
Op. capital - land & improvements ($)							−0.295*	−0.499**					−
Op. capital - total ($)							−0.324**	−0.492**					−
Average capital - total ($)							−0.280*	−0.473**					−
Cl. capital - total ($)							−0.285*	−0.453**					−
Op. capital - other stocks ($)	−0.217	−0.278	−0.101	−0.355			−0.206	−0.371**					−
Receipts													−
Receipts - off farm contracts ($)							0.086	−0.419**					−
Costs													−
Total services ($)			−0.1	−0.442*			−0.291*	−0.482**					−
Administration ($)	−0.202	−0.566**					−0.274*	−0.466**					−
Fertiliser ($)	−0.236	−0.298	−0.08	−0.187			−0.199	−0.414**					−
Fuel, oil & grease ($)							−0.245*	−0.326*					−
Total materials costs ($)			−0.142	−0.470**			−0.247*	−0.318*					−
Freight ($)			−0.091	−0.390*			−0.313*	−0.371**					−
Handling & marketing expenses ($)	−0.303*	−0.361*	−0.161	−0.305									−
Crop & pasture chemicals ($)	−0.288*	−0.285	−0.15	−0.149			−0.296*	−0.423**					−
Debt													−
Opening debt - total ($)	−0.284*	−0.385*					−0.393**	−0.472**					−
Closing debt - banks include State, CDB ($)	−0.229	−0.386*					−0.344**	−0.422**					−
Closing debt - working capital ($)	−0.166	−0.495**					−0.267*	−0.400**					−
Closing debt - total ($)	−0.211	−0.372*					−0.295*	−0.388**					−
Closing debt - land purchase ($)	−0.24	−0.13					−0.288*	−0.264*	−0.441**	−0.234			−
Closing debt - plant & livestock ($)			−0.183	−0.374*			−0.1	−0.199	−0.273*	−0.289			−
Family farm measures													−
Family farm income ($)					0.077	−0.201					0.039	−0.291*	−
Farm performance													−
Farm cash income ($)					0.054	−0.382*			0.177	−0.122	0.061	−0.24	−
Profit at full equity ($)					0.01	−0.285					−0.068	−0.286*	−
Other													+
Farm equity ratio at 30 June (%)	0.236	0.202					0.262*	0.148					+
Farm liquid assets ($)	−0.234	−0.481**	−0.290*	−0.512**									−

Table 1. Optimal vulnerability index correlates with seven financial categories using Spearman's nonparametric method. *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

adapt to the adverse impacts of climate change on farmers and crops. I can see that cooperation and coordination between farmers, scientists and policy-makers is mutually advantageous. Farmers provide survey data to scientists who can analyze this to obtain useful recommendations, which in turn helps officials design and implement effective policies to reduce the farms' loss due to climate change.

Method typologies benefit for the seven types of crop-drought vulnerability. In the light of the financial constraints, I can conceptualize seven generic types of crop-drought vulnerability (Table 3). Type 1 is constrained by capital in Murray Lands and Yorke Peninsula (422) for resilient wheat, in Mallee (221) and Central North (223) for three sensitive crops. Type 2, the farm asset-constrained vulnerability occurs in similar cases to the capital-constrained vulnerability. Type 3 is the vulnerability for three sensitive crops limited by total receipts in the Central West and Central North (121). The vulnerability limited by farm performance is Type 4 and it occurs for resilient oats in Eastern Darling Downs (321) and for three sensitive crops in Central West (122), Central North (223), and Eastern Darling Downs (321). For Type 5, the distributions of vulnerability constrained by family farm are similar to those of Type 4. The cost-induced vulnerability that is Type 6 occurs for resilient barley and oats in North West Slopes and Plains (121). Debt-induced vulnerability is represented in three resilient crops in some regions such as Darling Downs and Central Highlands in Queensland (322), where debt and interest payments become too onerous to be sustained by agricultural income. These typologies obtained from matching adaptive capacity and vulnerability effectively integrate space, time, crops, farmers' financial activities and climate change together, which imply the function of adaptive capacity.

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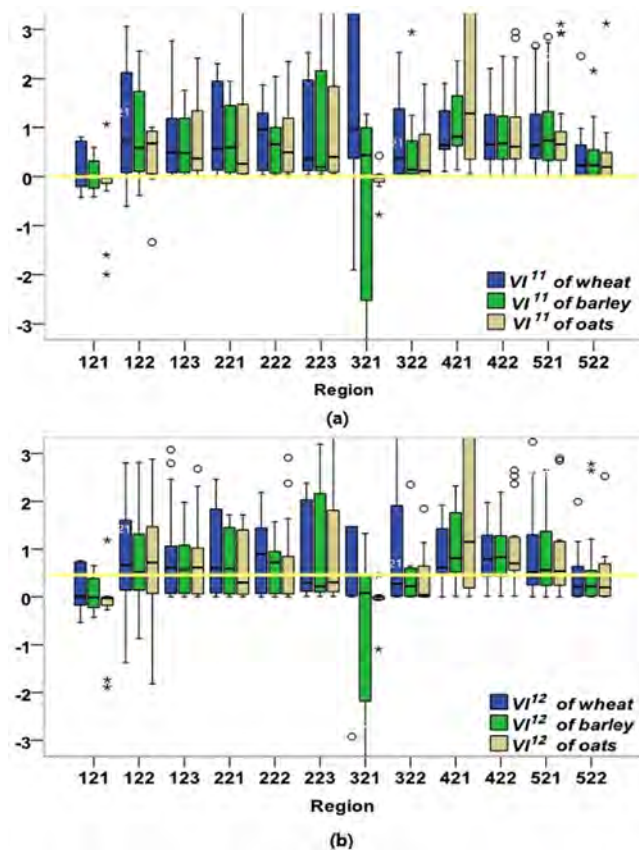
Figure 3. Box plots of the optimal vulnerability (e.g., VI[11] and VI[12]) for wheat, barley, oats, and their resilient and sensitive regions. The numbers under the horizontal axis present region codes.

Discussion: advantages of the "six typologies" frameworks

The "six typologies" frameworks can represent the heterogeneities of time, space and method as well as dynamic transitions and transformations between integration and typology in the assessments of vulnerability. They also provide seven useful generic types of adaptations. Although such frameworks have these advantages, they also have some disadvantages such as the various combinations of different types, the complex relationships between elements among different types and the different ways to calculate vulnerability, which will lead us to future research.

The "six typologies" framework emphasizes six heterogeneities. The environmental heterogeneity of the observed regions has shown that regional climatic variation and climate change, soil conditions and crop management are different at different dimensions and levels[61]. In addition, socioeconomic heterogeneity is worthy of more attention by "5W1H". Seven financial categories affect all resilient and sensitive cases for the three crops, which determine the financial heterogeneity of the vulnerabilities for barley, wheat and oats in Australia. I confirmed that (i) the level of capital and receipts reduce the vulnerability for wheat; farm performance decreases the vulnerability for oats, while family farm is negatively related to vulnerability for oats. Commonly, agricultural capital investments and higher crop receipts improve the returns of farming and reduce vulnerability[62]. Here, just wheat, barley and oats are affected by differential financial capital arrangements that show the heterogeneity of crops. Droughts can cause family farms to lose income diversity and increase their debt[63], potentially leading to a "cycle of poverty"[64] which can affect the inter-generational succession of family farms[65]. (ii) Cost and debt add to the vulnerability for wheat and barley. Drought imposes substantial costs for entities, public ventures, commercial organizations and governments[66]. Farmers may bear increased costs due to water scarcity or the necessity of irrigation during long-term severe droughts[67]. Benmelech and Dvir[68] demonstrated that short-term debt increases vulnerability. Our results support the idea that regional heterogeneity arises from environmental factors (e.g., local crops and climate change) and social factors (e.g., financial constraints), so creating a typology is useful for finding differences in each defined system. In total, the framework of "six typologies" reflects the heterogeneity of space, time, human factors, exposure, sensitivity and vulnerability.

Seven generic types of adaptations are valuable for making policy. I also construct seven generic types corresponding to adaptive strategies for each type of vulnerability in Australian wheat sheep zones. For Type 1 vulnerability, making additions to plant & equipment would upgrade agricultural technology. Planting more drought-tolerant varieties of crop would make more effective use of capital to help buffer harvests against drought. Alternatively, accumulating and utilizing farm equity to augment capital investment on the farm and using farm related liquid assets more efficiency may reduce Type 2 vulnerability. The methods of reducing Type 3

Duration	Lagged–one year						Same year					
Exposure	Drought index				Wet index		Drought index				Wet index	
Index	SNR	WSNR	SNRM	WSNRM	MSNR	MWSNR	SNR	WSNR	SNRM	WSNRM	MSNR	MWSNR
Wheat yield	−0.520**	−0.501**	−0.510**	−0.489**	0.505**	0.474**	−0.212**	−0.201**	−0.204**	−0.212**	0.157*	0.156*
Barley yield	−0.422**	−0.402**	−0.412**	−0.391**	0.453**	0.426**	−0.137*	−0.11	−0.12	−0.135*	0.09	0.1
Oats yield	−0.246**	−0.236**	−0.232**	−0.222**	0.314**	0.300**	−0.166*	−0.165*	−0.167*	−0.164*	0.193*	0.200**
Wheat failure	0.305**	0.289**	0.315**	0.291**	−0.250**	−0.247**	0.12	0.11	0.11	0.12	−0.09	−0.07
Barley failure	0.248**	0.227**	0.260**	0.234**	−0.205**	−0.208**	0.05	0.04	0.04	0.05	0	0
Oats failure	0.13	0.12	0.141*	0.13	−0.160*	−0.190*	0.147*	0.136*	0.133*	0.148*	−0.15	−0.13

Table 2. Droughts lagged by one year have a clear negative effect on crop yield. *Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Types	Financial constraints		Resilient region codes			Sensitive region codes			Adaptive strategies
			wheat	barley	oats	wheat	barley	oats	
			422	121	121	122	122	221	
			421	322	321	223	223	223	
			522	522	521	321	321	421	
			521	422	522	221	221	123	
1	Capital	221, 222, 223, 422	422	422		221, 223	221, 223	221, 223	Incentivize farmers to acquire additional plant & equipment and reduce opening capital.
2	Farm assets								Accumulate farm equity and use the farm's liquid assets more efficiently.
3	Total receipts	122, 223, 123, 222				122, 223	122, 223	223, 123	Protect agricultural receipts from transforming into off-farm industrial activity and avoid substitutes between crops.
4	Farm performance	122, 223, 321			321	122, 223, 321	122, 223, 321	223	Control the risk of adding farm cash income and profit at full equity through market mechanism, such as taking out a kind of insurance, through which farmers pay a small amount of cost to gain huge compensation for the huge economic loss due to future uncertainties.
5	Family farm								Improve family farm performance but protect income from transforming into off-farm industrial activities.
6	Cost	121, 322		121, 322	121				Reduce the cost of seed, fodder, fertiliser, crop & pasture chemicals, administration, rates and interest paid. Increase purchases of beef cattle, technological investments, capital investment, saving, etc.
7	Total debt	121, 322, 521, 522	521, 522	121, 322, 522	121, 521, 522				Reduce the risk of total debt, financial debt and land purchasing

Table 3. Typology of vulnerability was established by analysis of debt and cost, capital, receipts, assets, family and farm performance. The corresponding adaptive strategies for each type of vulnerability were determined by the financial characteristics of vulnerable cases for wheat, oats and barley. The numbers represent region codes.

vulnerability may include measures to keep agricultural prices stable and protecting agricultural receipts to avoid the huge transition from farm to off-farm industrial activities. Increasing farm cash income and profit through the market mechanism or government allowance can reduce Type 4 vulnerability[69]. For Type 5 vulnerability, increasing receipts and farm income through reorganizing the management style are potentially beneficial measures for increasing the revenues of family farms[70,71]. Deploying technological investments and improving special management skills may also be key strategies to reduce this vulnerability that could also involve reducing costs in agricultural processes such as planting, fodder, spraying, and fertilizer, which would be a good way to reduce Type 6 vulnerability[72]. One way to reduce debt-induced vulnerability is to supervise the risk of debt through developing financial tools and reducing land purchasing[73] (Table 3).

This typology of adaptations is intended to match the identified regions that are constrained by financial conditions with the resilient or sensitive regions for different crops. For example, Murray Lands and Yorke Peninsula (422) is a resilient region for wheat, while also being a capital and farm asset-constrained region. The match of both means capital and farm assets constrains the adaptive capacity for wheat there. Additionally, the resilient barley in Darling Downs and Central Highlands (322) is limited by cost because of the match of resilient typology of barley and the constraints of heterogeneous costs. This match is useful for creating and selecting the typology of vulnerability and adaptations.

Such a primary understanding is essential for a range of applications. First, the typology of adaptation provides a device that can help inform stakeholders as to what type of vulnerability they face and to adjust their adaptive strategies accordingly. Second, the typology puts forward a way that human factors can be better incorporated

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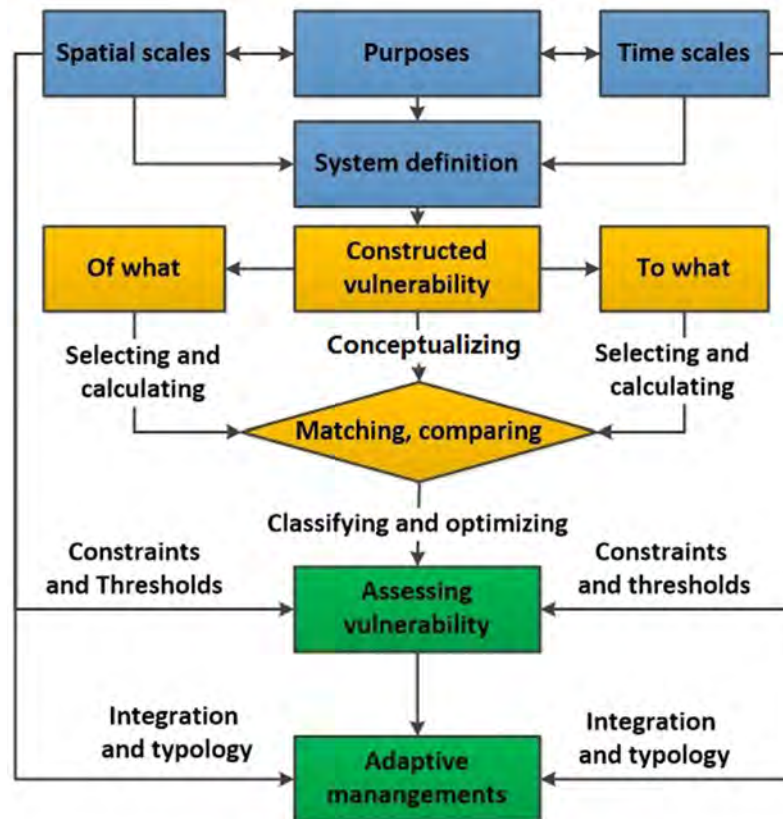
Figure 4. General steps to use the framework of "six typologies" in the vulnerability and adaptation management.

into crop–climate models, improving our appreciation of how underlying socioeconomic processes affect crop yields and showing where they are vulnerable to these changes. Third, the typology is still useful for those regions listed in Table 3, such as Eyre Peninsula where there is no match between limited regions and identified regions. If the resilient or sensitive regions have not been constrained by any of the listed categories in Fig. 3, I should consider more socioeconomic indicators beyond our list, such as human capital and crop prices, which give the policy-maker new guidelines and lead us to potential further work. If the regions exclude the resilient or sensitive cases where I know their socioeconomic features, there are at least two categories: the good crop harvest regions in drought conditions and the crop failure regions without drought, which require us to further rebuild the typology of the vulnerability and adaptation.

There are dynamic transitions and transformations between integration and typology. I construct and apply a plane grid that comprises six dimensions and six levels (see Fig. 1) to express integration and typology. This scheme is intended to assist with the common need for robust decision making within the process of assessing vulnerability and applying appropriate adaptation measures. I develop and test the new "adaptation pathways" through providing a linear sequence, and for instance, identify farmers' options for actions for reducing farm losses due to adverse climatic events, from more general to more specific using decomposition methods. Meanwhile, I define and match what the farms are concerned about such as, which crops, which climate elements, how to assess and respond to shocks, etc. in the vertical direction using inductive methods. The combinations of the inductive and deductive methods here means I have to match and optimize the integration and typologies in these six dimensions and levels when answering the questions of "5W1H"[42].

From the point of view of the user, I provide a set of general practical analysis steps (Fig. 4) through demonstrating the methodology of the Australian case. First, define the research systems through selecting and matching the most appropriate space, time scales, people and purposes. For example, I select farmers concerns about climate change in Australian wheat sheep zones in 1978–1999. Then conceptualizing, comparing and matching "vulnerability of what to what" is the key to managing vulnerability, among which exposure and sensitivity are used to select appropriate indicators and explore various calculation methods to optimize the measurement of vulnerability. For example, I explored crop-drought vulnerability through matching two kinds of CFI with six kinds of DI. The third is to assess vulnerability through classifying the cases according to their constraints and thresholds at appropriate spatial and temporal scales. Classifications of resilient and sensitive cases in the context of local limitations were also developed in the study. Finally, a typology of adaptations was derived according to the typology of vulnerability. This match, expressed in Table 3, helps us to clearly identify local adaptations according to local heterogeneity.

The two differences of scale-selections and lagged effects between the current study and its predecessors[26] further can show the usefulness of our methodology. It focused on the activity and process at monthly scale without considering human adaptation, and acknowledged that such lag effects existed but usually become short demonstrated by the response of vegetation activity, forest growth, and the ANPP to short drought[26]. In Fig. 1, six dimensions and six levels mean that we can select different time scales with the same crop in different spatial scales. The integration, matching and optimization as well as typology should be affected by the type of scientific question, the availability of data and the matches of different spatial and temporal scales in the assessments of vulnerability. Here I selected vulnerability of annual crop yield to drought in wheat sheep zones because I have no access to the available climatic data and the monthly livelihood capital. In contrast, I focus on the methodology of the research design to answer the questions "Who (some people) are concerned about how to adapt to the vulnerability of what to what in some place (where) at some time (when)?" I also emphasized on the socioeconomic adaptation that may cause the long-term lagged effects. For example, heterogeneous regions constraints determined different adaptive strategies, which means the next-year yield are affected by the decision of production according to today's response. Such decision processes include the lag-influence in crop planting. Therefore, I considered the lagged effect of the drought on annual crop yield.

Conclusions

Who (some people) are concerned about how to adapt to the vulnerability of what to what in some place (where) at some time (when)? It means the adaptation pathway should transit and transform integration into typology among environmental types (i.e., types of time, space, who) and vulnerability types (i.e., exposure, sensitivity, and adaptive capacity). I illustrated the hypothesis that the process of assessing vulnerability and selecting adaptations can be enhanced by using a combination of integration, optimization and typology based on heterogeneities in space, time, social factors, exposure, sensitivity and adaptive capacity, using the case of Australia's wheat sheep zones over the period 1981–1999. Our analysis framework of integration and typology of vulnerability can be of benefit to policy makers in determining appropriate adaptive strategies, and for crop–climate researchers to integrate socioeconomic factors into crop models. Although there are many advantages to the so called "six types" framework, the complexity due to the many types and factors and their interaction represents one of its disadvantages. This provides an opportunity for further research. In the case of Australia in particular, further work would be useful to select more socioeconomic indicators, such as human capital and develop more sub-classifications, such as regions of good harvest in drought and crop failure regions without drought, which I leave for further work.

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Author Contributions

Conceived and designed the experiments: J.H. Performed the experiments: J.H. Analyzed the data: J.H. Contributed reagents/materials/analysis tools: J.H. Wrote the paper: J.H.

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Monitoring and assessing fruit freshness in IOT-based e-commerce delivery using scenario analysis and interval number approaches

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ABSTRACT

We are concerned with the monitoring and assessment of in-transit fruit freshness in e-commerce deliveries. After comparing the fulfillment processes of fresh fruit transportation in traditional retailing and e-retailing, we formulate an Internet of Things–based framework for monitoring fruit e-commerce deliveries. Based on the fulfillment operations and monitoring modules of the framework, we propose an approach based on a two-stage scenario for assessing the freshness of in-transit fruits. In the first stage, we use a learning-by-doing mechanism to develop a scenario construction method to automatically obtain the most appropriate delivery environment and the occurrence probability for each scenario. In the second stage, we integrate the interval comparison technique into the scenario analysis method to address the freshness assessment of in-transit fruits. The effectiveness and advantages of our approach are verified using numerical simulations.

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1. Introduction

With the development of e-commerce and advanced information technologies, retailing has experienced a revolution. Currently, e-retailing has advantages over traditional retailing in many areas, such as books, music, clothing and electrical appliances. However, fresh produce presents many challenges for e-retailing due to characteristics such as perishability and high-cost logistics, especially in developing countries [3,17]. Recently, the Chinese government and e-commerce giants have tried to break into fresh produce e-retailing. One of the difficulties encountered is determining how to monitor and control the freshness of in-transit fresh produce [12]. Obviously, these tasks are especially difficult without help from advanced information technologies [16,20,30]. In an empirical study, Shin and Eksioglu [32] observed that the application of radio frequency identification devices (RFIDs) considerably improves labor productivity in U.S. retail supply chains.

In the literature, some recent studies have applied related information technologies to the monitoring and control of in-transit fresh produce, presenting specific solutions. For example, Ruiz-Garcia et al. [28] applied ZigBee-based wireless sensors to the monitoring of fruit logistics, analyzed the battery life of the sensors, and evaluated the reliability of the whole system. Abad et al. [1] presented a monitoring system consisting of a smart RFID tag subsystem located in the delivery trucks and a commercial reader/writer subsystem located in the delivery nodes, reporting advantages of this system in an intercontinental

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fresh fish supply chain. Kang et al. [11] presented a simulation method to assess the performance of optimization models and to determine the key parameter values in a RFID sensor–based cold transportation system, while Mainetti et al. [18] applied radio frequency technologies and EPCglobal standards to develop a traceable system of fresh vegetable products. Mejjaoulia and Babiceanu [19] presented an integrated RFID sensor network system for optimizing the transportation of perishable products, indicating that the system was helpful for reducing operation costs. Xiao et al. [40] argued that heavy sensory data needs in traditional monitoring systems reduced data transmission efficiency; thus, they integrated a wireless sensor network (WSN) with compressed sending (CS) to develop a temperature monitoring system for frozen and chilled aquatic products. Finally, Trebar et al. [37] used RFID sensors to monitor the temperatures of styrofoam boxes during the transport of fresh fish and proposed a time- and energy-saving method for packing fish.

The above studies have made specific contributions to the monitoring and control of fresh produce by applying advanced information technologies and providing practical support for the transportation of fresh produce. However, most studies have focused on conventional supply chains, paying little attention to the e-commerce delivery of fresh produce. In e-retailing, the delivery of fresh produce is quite different from traditional transportation, which creates new challenges [13]. Meanwhile, different kinds of fresh produce have specific characteristics in e-fulfillment [16]. Motivated by these observations, in this work, we are concerned with the monitoring of fresh fruit in e-commerce deliveries.

Monitoring and control systems aim to maintain the freshness of perishable products while in transit. However, loss of freshness may result at any point during the e-fulfillment process of fresh fruit orders. Thus, real-time assessment of these products is key to controlling their freshness. The e-fulfillment of fruit orders often involves multiple participants conducting their respective delivery services [25]. The complexity of and uncertainty in this process make monitoring and assessing of the freshness of in-transit fruits difficult. Scenario analysis is an effective method for analyzing complex uncertainty by considering both possible events and their occurrence probabilities [5,8,15]. As mentioned above, the e-fulfillment of fresh fruit orders involves multiple operation links and service participants, creating a process that is full of uncertainty. The freshness of in-transit fruits will vary in different fulfillment situations. Thus, scenario analysis is suitable for recognizing different e-fulfillment situations for fruit orders.

Similarly, it is increasingly popular to develop models using fuzzy or interval information in the literature due to uncertainty [14,31,34,35]. The data, such as temperature and humidity information, produced by fruit monitoring sensors are often interval values. Classic scenario analyses cannot be directly used to address these interval data in each possible scenario. Fortunately, a body of literature addresses interval comparison methods [4,45,47]. The integration of interval comparison methods into classic scenario analysis may provide feasible solutions for assessing the freshness of in-transit fruits in different interval situations.

Motivated by the above observations, in this work, we present an Internet of Things (IOT)-based framework for monitoring fruit e-commerce delivery. We use scenario analysis methods to construct delivery scenarios in the e-fulfillment of fruit orders to provide corresponding assessments of freshness at each step in the delivery process. Meanwhile, based on the characteristics of the sensor data, we integrate interval comparison into the scenario-based freshness assessment approach.

To sum up, in this work, we make the following contributions:

(i) We compare fresh fruit transportation in traditional retailing and e-retailing and present an IOT-based framework for monitoring fruit e-commerce deliveries. Detailed descriptions of fruit e-fulfillment operations, as well as of the modules in the IOT-based monitoring framework, provide a basis for developing a scenario-based approach to assessing in-transit fruit freshness.

(ii) We divide the freshness assessment scenario into a scenario construction stage and a freshness assessment stage. We then use a learning-by-doing mechanism to develop a scenario construction method that can automatically obtain both the most suitable environment for each scenario and the occurrence probability of each scenario from practical delivery operations.

(iii) We integrate interval comparison techniques into scenario analysis methods to assess the freshness of in-transit fruits. This integrated approach assesses freshness by comparing the similarity of the sensing environment to the most suitable environment for each scenario.

The remainder of this paper is organized as follows. Section 2 presents an IOT-based framework for monitoring fruit e-commerce deliveries, providing the basis for the scenario analysis portion of the freshness assessment. In Section 3, we propose a scenario-based approach for assessing the freshness of in-transit fruits, which is divided into a scenario construction stage and a freshness assessment stage. Section 4 presents the experimental results showing the effectiveness and advantages of our contributions. Section 5 concludes the work and provides recommendations for future study.

2. An IOT-based framework for monitoring fruit e-commerce delivery

2.1. Fruit e-commerce delivery

In traditional commerce, fresh fruits are often sold to end consumers through multiple intermediaries, such as wholesalers, distributors and retailers, as Fig. 1 shows. In the traditional retailing channel, fresh fruits are first picked on farms and then transported to local processing centers (LPCs) where fruits are washed, cooled, packaged, and so on. Then, the processed fruits are often purchased by wholesalers who will either store the fruits in their warehouses or directly transport
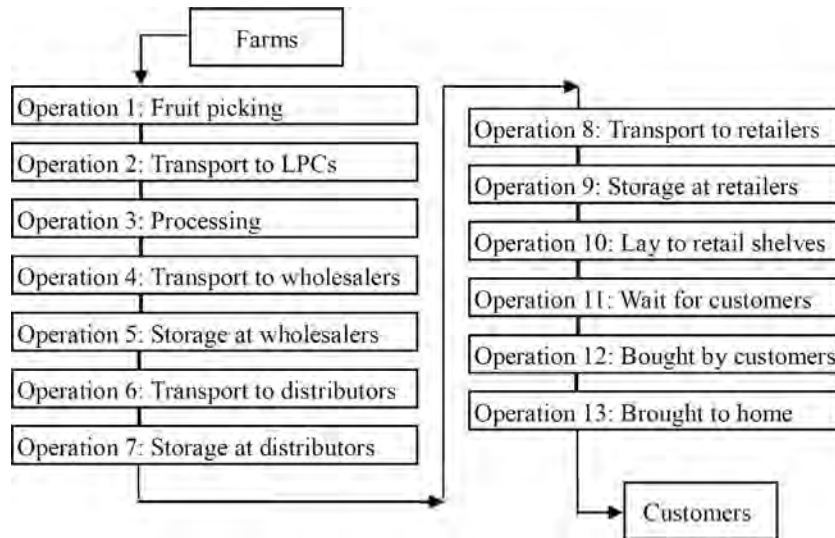
Fig. 1. Traditional fruit commerce delivery.
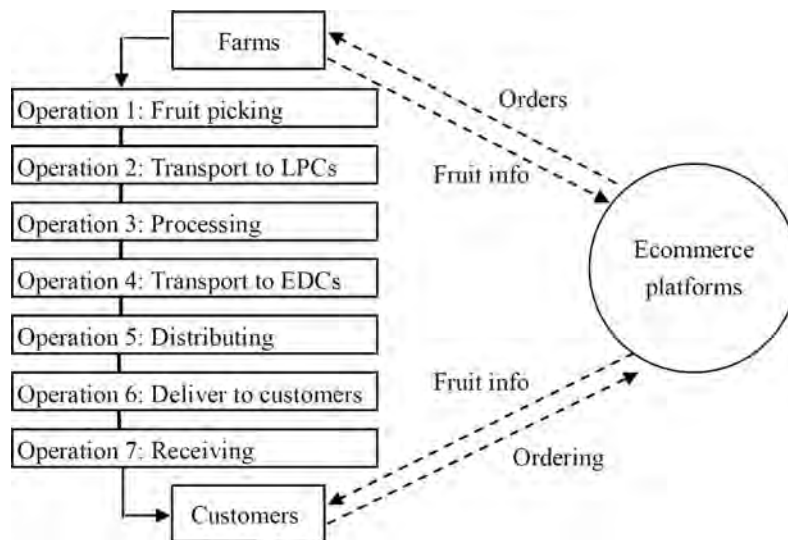
Fig. 2. Farm-to-table fruit e-commerce delivery.

them to their distributors. After receiving the fruits, distributors in consumption areas often deliver fruits to their respective retailers. Finally, these retail-ready fruits have to be stocked on retailers' shelves until customers come into the stores and buy them.

Due to the complicated process of moving produce from farmers to retailers illustrated above, it often takes a long time and high costs before retailers can stock fruits on their shelves for end consumers to buy. In order to maintain freshness, fruits are often transported in cold chain systems, although a large proportion of fruits will spoil during transport and be thrown away regardless [44]. As a result, fresh fruits often have relatively high retail prices. However, e-commerce is changing this picture.

Having reshaped common product retailing, e-commerce is shifting to live and fresh products. In fruit e-commerce, the long traditional supply chain from farm to end customer shown in Fig. 1 is often greatly shortened. One typical fruit type of e-retailing is "farm-to-table" commerce [43]. Fig. 2 shows the basic process involved in farm-to-table fruit e-commerce (at end distribution centers (EDCs), fruits are transited from the trunk transport to the last mile delivery): farms post fruit supply information on e-commerce platforms when, or even before, the fruits ripen; customers submit orders to farms through e-commerce platforms; finally, farms pick the fruits based on the orders they receive and deliver them to the appropriate end customers.
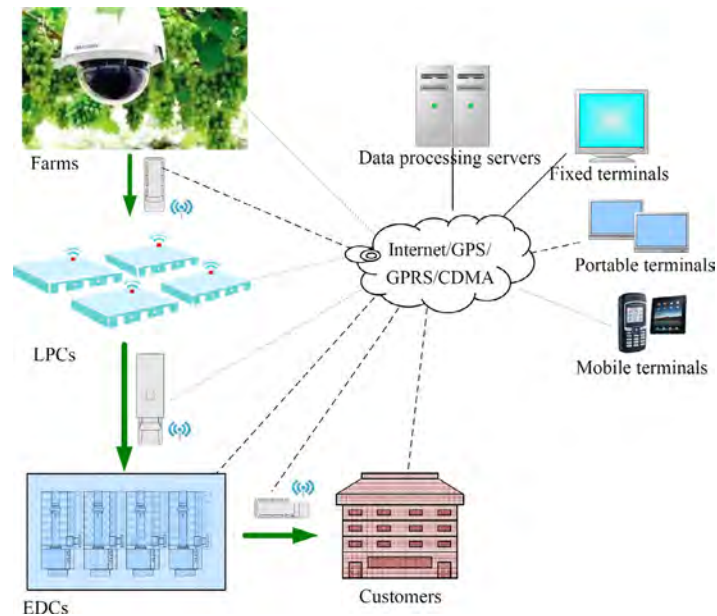
Fig. 3. IOT-based monitoring framework of fruit e-commerce delivery.

Compared with traditional fruit retailing, the farm-to-table fruit e-commerce described in in Fig. 2 has some of the following specific advantages:

(1) Online farms can sell their fruits before picking them. In the traditional business model, farms have to pick their fruits and transport them to retailers through multiple intermediaries before customers select from among the fruits on the retailers' shelves. Obviously, the retailing time is much longer in the e-commerce model.

(2) Fruits are directly delivered from the farms to the end customers. Thus, fruit retailing is changing from "push" to "pull" modes with the introduction of e-commerce. In the "pull" mode, the flow of fruits is directed, which often greatly improves freshness and reduces costs.

(3) The number of intermediate links is greatly reduced. As Fig. 2 shows, farm-to-table fruit e-commerce delivery generally consists of seven operations—nearly one-half of the number of delivery links as in traditional fruit commerce delivery, as shown in Fig. 1. This change not only shortens transportation times but also reduces costs.

(4) Due to directed transportation and fewer intermediaries, it is also easier to track the supply chain in fruit e-commerce, which is helpful when addressing fruit safety concerns.

However, fruit e-commerce inevitably encounters some challenges during the fulfillment of online orders. One prominent issue is monitoring and controlling the freshness of multiple kinds of fruits in transit. This point is the key to fruit e-commerce success.

2.2. An IOT-based monitoring framework

Based on the farm-to-table fruit e-commerce delivery process shown in Fig. 2, we present a corresponding monitoring framework using IOT-related technologies, such as global position systems (GPS), RFID sensor tagging, wireless sensor networks, mobile communication networks (e.g., GRPS/CDMA) and the Internet, as indicated in Fig. 3.

This framework consists of eight main modules. Each module has a specific role and is equipped with corresponding IOT-related technologies.

(1) Farm module. With the wide application of advanced information and control technologies on farms, extensive contributions have been made to intelligent farming (i.e., precision agriculture). For details, the readers are referred to the extant works [6,10,33]. In our framework, the farm module could collect environment data on farms using equipment such as temperature sensors, humidity sensors, photosensitive sensors, CO_2 sensors, soil sensors and cameras. The sensor information collected in this module is transferred to data processing servers and stored in the servers.

(2) Vehicle module. The vehicle module is used to physically connect the farm, LPC, EDC and customer modules. Vehicles are equipped with cooling and sensing subsystems. The objective of the cooling subsystem is to maintain the vehicle environment within the most suitable conditions for maintaining the freshness of in-transit fruits. The sensing subsystem is a precondition for controlling the vehicle environment. In our framework, the sensing subsystem is part of a common RFID sensor-based system [11,19,46].

(3) LPC module. After being picked on farms, fruits are transported to LCPs. As mentioned above, fresh fruit processing includes washing, cooling, and packaging in the LPC module. Another key operation in the LPC module is the tagging of RFID sensors to fruits. Information written in the RFID sensors might include places of origin, growth conditions, processing procedures, transport service providers, designated EDCs, and end customers. Using this information, fruit orders can be smoothly transported from LPCs to customers.

(4) EDC module. In this module, fruits are collected from various LPCs and distributed to their corresponding customer areas. A specific EDC often receives fruit orders from various farms, and a specific transport vehicle often visits multiple EDCs at which fruits need to be transferred from large transport trucks to medium-sized or small vehicles. Traditional manual sorting at EDCs is often time consuming. In our framework, RFID readers, which can automatically recognize and sort tagged fruits into batches, are used in the EDC module to reduce the time needed to transfer fruit orders at EDCs.

(5) Customer module. Currently, there are three main receiving modes: home delivery, intelligent reception, and third-party receiving [2,9,24,39]. In the home delivery mode, fruit orders are delivered directly to customers. This mode is currently the most common mode. In intelligent reception, fruit orders are delivered to boxes that are equipped with cooling and messaging systems, and customers receive text message alerts as soon as their fruit orders are placed into the reception boxes. In the third-party receiving mode, fruit orders are delivered to third parties, such as community service centers and local retail stores.

(6) Communication module. The communication module consists of various subsystems, such as local area networks, wireless sensor networks, GPS, mobile communication networks and the Internet. This module connects all related parties, including farms, transport service providers, LPCs, EDCs and customers, and almost all the information is disseminated via the communication module.

(7) Server module. The server module is the heart of the information processing framework. The data are stored and processed by data processing servers, which can be either centralized or decentralized [41]. The key role of this module is to assess the freshness of the monitored fruits and send timely operation commands. Thus, the accuracy of freshness assessment is very important to the overall framework [38]. In the following section, we will provide specific solutions to this problem.

(8) Terminal module. All information and operation commands for the in-transit fruits should be accessible at any time and place through various terminals, such as fixed, portable and mobile terminals. These terminals can be used by farms, transporters, LPCs, EDCs, and customers.

3. A scenario-based approach for assessing the freshness of in-transit fruits

As mentioned in the Introduction, scenario analysis is a prediction and assessment technique for analyzing both the possible events and the occurrence probability of each event. This technique has been widely used for complicated decision-making issues. Although fresh fruit e-retailing is significantly simpler than traditional fruit retailing, uncertainties remain, and loss of freshness will differ based on the operations and environments of the e-fulfillment process. Thus, in this work, we analyze scenarios for assessing the freshness of in-transit fruits and then develop a two-stage scenario-based assessment approach.

3.1. Scenario analysis of freshness assessment

Determining how to represent scenarios is a precondition of scenario analysis. As we can see in Fig. 2, fruit e-commerce delivery consists of multiple operations implemented in the corresponding environment, and each operation often has an impact on the total delivery time. In addition, different kinds of fruits often have different shelf lives. We thus present a scenario representation method for assessing the freshness of in-transit fruits along four dimensions:

$$S = \{(F, O, E, T)\} \tag{1}$$

where S represents the scenario consisting of four dimensions for which fruit freshness is assessed: Fruit (F), Operation (O), Environment (E) and Time (T). Each dimension has specific effects on the freshness of in-transit fruits, as detailed in the following.

F represents the characteristics of fruits. For example, fruits have specific attributes, such as perishability and pressure resistance. These attributes directly impact their shelf lives in both refrigerated and conventional environments. In this work, we divide fruits into eight categories based on their characteristics, as shown in Table 1.

We can also express fruit categories using the following set form:

$$F = \{(ResiT, ResiH, ResiP)\} \tag{2}$$

where $ResiT = \{good, bad\}$ represents resistance to temperature, $ResiH = \{good, bad\}$ represents resistance to humidity, and $ResiP = \{good, bad\}$ represents resistance to pressure. Obviously, F includes 8 (2^3) fruit categories, that is, $F = \{F_i, 1, 2, ..., 8\}$.

O indicates the current module of the in-transit fruits. As analyzed in Section 2.2, the delivery of fruit orders consists of eight main operations that affect the freshness of in-transit fruits. For example, the same fruit will have a different shelf life

Table 1
Fruit categories based on their characteristics.

Resistance to temperature	Resistance to humidity	Resistance to pressure	Categories
Good	Bad	Bad	F_1
		Good	F_2
	Good	Bad	F_3
		Good	F_4
Bad	Good	Good	F_5
		Bad	F_6
	Bad	Good	F_7
		Bad	F_8

depending on its maturity when it is picked. Unripe fruits often have longer shelf lives than ripe ones. Other operations are affected by whether they occur in a cooling environment. We express the detailed operating situations as follows:

$$O = \{(Oper1, Oper2, Oper3, Oper4, Oper5, Oper6, Oper7)\} \tag{3}$$

where $Oper1 = \{unripe, ripe\}$ represents the maturity of the fruits when they are picked, $Oper2 = \{cooling, non-cooling\}$ represents whether Operation 2 (i.e., Transport to LPCs) in Fig. 2 occurs in a cooling environment, and $Oper3 \sim Oper7$ have the same meaning as $Oper2$. As we can see, O includes 128 (2^7) operating situations, that is, $O = \{O_j, j = 1, 2, ..., 128\}$.

E represents the environment in which in-transit fruits are kept. Deterioration mainly results from the actions of enzymes in the fruits, and temperature and humidity directly impact the activation of these enzymes [12]. Meanwhile, pressure also impacts the loss of freshness, especially for fragile or ripe fruits. Thus, there are often ideal temperature, humidity and pressure ranges for maintaining the shelf life of a given kind of fruit. We express the environment situation as:

$$E = \{(Temp, Humi, Pres)\} \tag{4}$$

where $Temp$, $Humi$ and $Pres$ represent the temperature, humidity and pressure, respectively, in the environment. In this work, we categorize these environmental factors as good and bad. Thus, E also includes 8 (2^3) environment situations, that is, $E = \{E_k, k = 1, 2, ..., 8\}$.

T represents the time needed for each operation. The same fruits in the same operation and environment situation may lose their freshness at different rates if operations take varying amounts of time. Generally, the longer the operation time, the more freshness is lost in transit. Based on the fruit e-commerce delivery process described in Fig. 2, we express the time situation using the following set:

$$T = \{(Time1, Time2, Time3, Time4, Time5, Time6, Time7)\} \tag{5}$$

where $Time1 \sim Time7$ represent the time needed for each operation. For convenience, we express time using two levels, long and short, that is, $Time1 = \{long, short\}$. Other time situations are also described. Thus, T includes 128 (2^7) time situations, that is, $T = \{T_l, l = 1, 2, ..., 128\}$.

To sum up, the freshness of in-transit fruits will depend on the scenario. Although we express the four dimensions of each scenario using simple levels, there are still up to 2^{20} ($2^3 \times 2^7 \times 2^3 \times 2^7$) scenarios. Thus, it is not feasible to conduct a freshness assessment of in-transit fruits conditional on delivery service providers knowing all the scenarios. Additionally, the translation of a practical status into the corresponding levels is not easy due to the uncertainty in real-world situations. Based on these observations, we divide scenario-based freshness assessment into two stages: scenario construction and freshness assessment. In the following subsections, we detail each stage.

3.2. Stage I: scenario construction

In the scenario construction stage (shown in Fig. 4), we consider the Fruit (F) and Operation (O) situations. According to the addition principle in probability theory, we obtain the following formulas:

$$\sum_{i=1}^{8} p(F_i) = 1 \tag{6}$$

$$\sum_{j=1}^{128} p(O_j/i) = 1 \quad \forall i = 1, 2, ..., 8 \tag{7}$$

where $p(F_i)$ represents the probability of F_i, $i = 1, 2, ..., 8$, O_j/i represents the jth O situation under the ith F situation, and $p(O_j/i)$ represents the conditional probability of O_j, $j = 1, 2, ..., 128$ under F_i, $\forall i = 1, 2, ..., 8$.

The aim of the scenario construction stage is to determine the most suitable Environment (E) and the probabilities of the $2^{10}(2^3 \times 2^7)$ scenarios, that is, to determine $E_{best/j/i} = \{Temp_{best/j/i}, Humi_{best/j/i}, Pres_{best/j/i}\}$, $p(F_i)$ and $p(O_j/i)$.
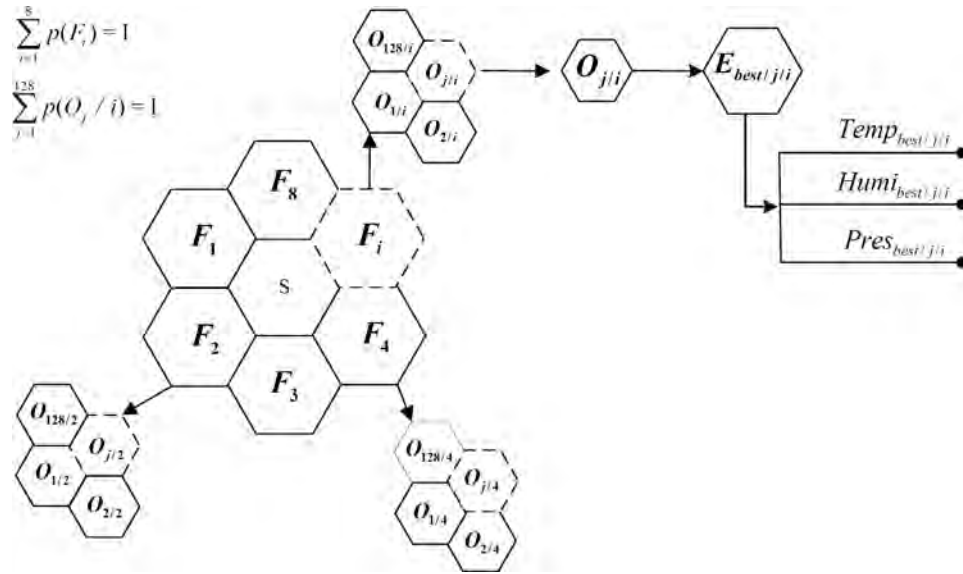
Fig. 4. Scenario construction stage.

In this stage, we use the learning-by-doing mechanism to obtain $p(F_i)$, $p(O_j/i)$ and $E_{best/j/i}$. In the IOT-based framework in Fig. 3, the detailed process for a given fruit e-commerce company is as follows:

Step 1: Initialization. Set $p(F_i) = 0$, $p(O_j/i) = 0$, and $E_{best/j/i} = \{0, 0, 0\}$, $i = 1, 2, ..., 8, j = 1, 2, ..., 128$. Use G_i^t and H_{ij}^t to record the occurrence frequency of F_i and O_j/i, respectively (where t is a counter, $G_i^0 = 0$, and $H_{ij}^0 = 0$). Use $Temp_{t/j/i}$, $Humi_{t/j/i}$ and $Pres_{t/j/i}$ to record the temperature, humidity and pressure at t, respectively. These variable values and the whole process are stored in the server module and are editable.

Step 2: After finishing a delivery, all the environment information is transmitted to the server module by the communication module, and $Temp_{t/j/i}$, $Humi_{t/j/i}$ and $Pres_{t/j/i}$ are recorded into the server module. Meanwhile, customers in the customer module evaluate whether the received fruits are fresh. If the evaluation indicates that the fruits are fresh, $t = t + 1$, go to Step 3; if not, ignore this delivery and proceed to Step 5.

Step 3: Decision-makers in the terminal module determine which of the 1024 scenarios the delivery belongs to, according to the fruit characteristics and operations that took place in the farm, vehicle, LPC, EDC and customer modules. Based on this judgement, update $G_i^t = G_i^{t-1} + 1$ and $H_{ij}^t = H_{ij}^{t-1} + 1$ if F_i and O_j/i occur; otherwise, keep $G_i^t = G_i^{t-1}$ and $H_{ij}^t = H_{ij}^{t-1}$.

Step 4: Update $p(F_i) = G_i^t / \sum_{i=1}^{8} G_i^t$ and $p(O_j/i) = H_{ij}^t / \sum_{i=1}^{8} \sum_{j=1}^{128} H_{ij}^t$ in the server module. If $H_{ij}^t \neq 0$, update $Temp_{best/j/i} = \sum_{1}^{t} Temp_{t/j/i} / H_{ij}^t$, $Humi_{best/j/i} = \sum_{1}^{t} Humi_{t/j/i} / H_{ij}^t$ and $Pres_{best/j/i} = \sum_{1}^{t} Pres_{t/j/i} / H_{ij}^t$ in the server module, Otherwise, update $Temp_{best/j/i} = 0$, $Humi_{best/j/i} = 0$ and $Pres_{best/j/i} = 0$ in the server module.

Step 5: If $G_i^t \neq 0, H_{ij}^t \neq 0, \forall i = 1, 2, ..., 8, j = 1, 2, ..., 128$ or $t = Max_t$, go to Step 6. Otherwise, proceed to Step 2. Here, Max_t expresses the maximum learning time. As we can see, we use two stopping criteria. One is $G_i^t \neq 0, H_{ij}^t \neq 0, \forall i = 1, 2, ..., 8, j = 1, 2, ..., 128$, which means that all the situations are traversed. The other is the maximum learning time.

Step 6: Termination. Store $p(F_i)$, $p(O_j/i)$ and $E_{best/j/i} = \{Temp_{best/j/i}, Humi_{best/j/i}, Pres_{best/j/i}\}$ in the server module as the rules for conducting fruit freshness assessment of future e-fulfillment orders.

Using the above learning-by-doing process, we could specify the 1024 scenarios automatically. Similarly, we could specify 2^{20} ($2^3 \times 2^7 \times 2^3 \times 2^7$) scenarios by considering the four situations in farm-to-table fruit e-commerce delivery and 2^{32} ($2^3 \times 2^{13} \times 2^3 \times 2^{13}$) scenarios in traditional fruit commerce delivery. We will use experimental simulations to compare the efficiency of the three scenario construction methods in Section 4.

3.3. Stage II: freshness assessment

In Stage I, we could use a learning-by-doing mechanism to determine the most suitable Environment (E), as well as the probabilities of the 2^{10} scenarios, that is, $E_{best/j/i} = \{Temp_{best/j/i}, Humi_{best/j/i}, Pres_{best/j/i}\}$, $p(F_i)$ and $p(O_j/i)$. Then, it is our final aim to assess the freshness of in-transit fruits by comparing the current situation with the scenarios constructed in Stage I. In this subsection, we will address the assessment issue.

As Kang et al. stated [11], there are two main sensing types: interval sensing and immediate sensing. In our IOT-based monitoring framework, we use the interval sensing method. Sensors located in the delivery environment send temperature, humidity and pressure information in a given interval. Here, we use three interval variables to represent the sensing

environment:

$$E_{sensing/j/i} = \{\bar{T}emp_{sensing/j/i}, \bar{H}umi_{sensing/j/i}, \bar{P}res_{sensing/j/i}\} \tag{8}$$

$$\bar{T}emp_{sensing/j/i} = [Temp_{sensing/j/i}^{lower}, Temp_{sensing/j/i}^{upper}] \tag{9}$$

$$\bar{H}umi_{sensing/j/i} = [Humi_{sensing/j/i}^{lower}, Humi_{sensing/j/i}^{upper}] \tag{10}$$

$$\bar{P}res_{sensing/j/i} = [Pres_{sensing/j/i}^{lower}, Pres_{sensing/j/i}^{upper}] \tag{11}$$

where $\bar{T}emp_{sensing/j/i}$, $\bar{H}umi_{sensing/j/i}$ and $\bar{P}res_{sensing/j/i}$ are intervals representing the temperature, humidity and pressure, respectively, of situation O_j/i. $Temp_{sensing/j/i}^{lower}$, $Humi_{sensing/j/i}^{lower}$ and $Pres_{sensing/j/i}^{lower}$ are the lower bounds, while $Temp_{sensing/j/i}^{upper}$, $Humi_{sensing/j/i}^{upper}$ and $Pres_{sensing/j/i}^{upper}$ are the upper bounds. The widths of $\bar{T}emp_{sensing/j/i}$, $\bar{H}umi_{sensing/j/i}$ and $\bar{P}res_{sensing/j/i}$ are fixed due to the sensing settings.

As we can see, the closer the sensing environment $E_{sensing|j|i}$ is to the most suitable environment $E_{best|j|i}$, the fresher the fruits will be. To measure the proximity of $E_{sensing|j|i}$ to $E_{best|j|i}$, we should first determine how to compare $Temp_{best|j|i}$ and $\bar{T}emp_{sensing/j/i}$, $Humi_{best|j|i}$ and $\bar{H}umi_{sensing/j/i}$, and $Pres_{best|j|i}$ and $\bar{P}res_{sensing/j/i}$. That is, we should determine how to compare crisp and interval numbers.

Due to real-world uncertainty, interval and fuzzy numbers have been widely used in the literature [21–23,27,36,42]. Sengupta and Pal [29] proposed an interval comparison index, and Giove [7] extended it to an index for comparing crisp and interval numbers. Further, in our previous work, we have considered decision-maker optimism to develop a preference-based method for comparing crisp and interval numbers [26]. We showed the advantage of our method over those of Sengupta and Pal [29] and Giove [7]. In this work, we use our preference-based method to compare $Temp_{best|j|i}$ in $E_{best|j|i}$ (crisp) with $\bar{T}emp_{sensing/j/i}$ in $E_{sensing|j|i}$ (interval) as follows:

$$\delta(Temp_{best/j/i}, \bar{T}emp_{sensing/j/i}) = \frac{o(Temp_{best/j/i}) - o(\bar{T}emp_{sensing/j/i})}{\omega(Temp_{best/j/i}) + \omega(\bar{T}emp_{sensing/j/i}) + 1} \tag{12}$$

where $o(Temp_{best/j/i}) = \gamma Temp_{best/j/i} + (1-\gamma)Temp_{best/j/i} = Temp_{best/j/i}$, and $o(\bar{T}emp_{sensing/j/i}) = \gamma Temp_{sensing/j/i}^{lower} + (1-\gamma)Temp_{sensing/j/i}^{upper}$ denote the perceived values of $Temp_{best|j|i}$ and $\bar{T}emp_{sensing/j/i}$, $\omega(Temp_{best/j/i}) = \frac{1}{2}(Temp_{best/j/i} - Temp_{best/j/i}) = 0$ and $\omega(\bar{T}emp_{sensing/j/i}) = \frac{1}{2}(Temp_{sensing/j/i}^{upper} - Temp_{sensing/j/i}^{lower})$ denote the half-widths of $Temp_{best|j|i}$ and $\bar{T}emp_{sensing/j/i}$, respectively. That is:

$$\delta(Temp_{best/j/i}, \bar{T}emp_{sensing/j/i}) = \frac{Temp_{best/j/i} - (\gamma Temp_{sensing/j/i}^{lower} + (1-\gamma)Temp_{sensing/j/i}^{upper})}{\frac{1}{2}(Temp_{sensing/j/i}^{upper} - Temp_{sensing/j/i}^{lower}) + 1} \tag{13}$$

where γ denotes the degree of decision-maker optimism. As we can see, the smaller $\left|\delta(Temp_{best/j/i}, \bar{T}emp_{sensing/j/i})\right|$, the closer $\bar{T}emp_{sensing/j/i}$ is to $Temp_{best|j|i}$.

Similarly, we have:

$$\delta(Humi_{best/j/i}, \bar{H}umi_{sensing/j/i}) = \frac{Humi_{best/j/i} - (\gamma Humi_{sensing/j/i}^{lower} + (1-\gamma)Humi_{sensing/j/i}^{upper})}{\frac{1}{2}(Humi_{sensing/j/i}^{upper} - Humi_{sensing/j/i}^{lower}) + 1} \tag{14}$$

$$\delta(Pres_{best/j/i}, \bar{P}res_{sensing/j/i}) = \frac{Pres_{best/j/i} - (\gamma Pres_{sensing/j/i}^{lower} + (1-\gamma)Pres_{sensing/j/i}^{upper})}{\frac{1}{2}(Pres_{sensing/j/i}^{upper} - Pres_{sensing/j/i}^{lower}) + 1} \tag{15}$$

After obtaining the above $\delta(Temp_{best/j/i}, \bar{T}emp_{sensing/j/i})$, $\delta(Humi_{best/j/i}, \bar{H}umi_{sensing/j/i})$ and $\delta(Pres_{best/j/i}, \bar{P}res_{sensing/j/i})$, we can calculate the proximity of $E_{sensing|j|i}$ and $E_{best|j|i}$ using:

$$C(E_{sensing/j/i}, E_{best/j/i}) = w_1\left|\delta(Temp_{best/j/i}, \bar{T}emp_{sensing/j/i})\right| + w_2$$
$$\left|\delta(Humi_{best/j/i}, \bar{H}umi_{sensing/j/i})\right| + w_3\left|\delta(Pres_{best/j/i}, \bar{P}res_{sensing/j/i})\right| \tag{16}$$

where w_1, w_2 and w_3 represent the weights of temperature, humidity and pressure, respectively, for maintaining the freshness of in-transit fruits. According to probability theory, we could use the $p(O_j/i)$ to calculate the weights as follows:

$$w_1 = \frac{DW_1}{DW_1 + DW_2 + DW_3} \tag{17}$$

$$w_2 = \frac{DW_2}{DW_1 + DW_2 + DW_3} \tag{18}$$

Table 2

Comparison of the three scenario construction methods.

Method	Situations considered	Number of scenarios
IOT-based FO method	Fruit, Operation	2^{10} $(2^3 \times 2^7)$
IOT-based FOET method	Fruit, Operation, Environment, Time	2^{20} $(2^3 \times 2^7 \times 2^3 \times 2^7)$
Traditional FOET method	Fruit, Operation, Environment, Time	2^{32} $(2^3 \times 2^{13} \times 2^3 \times 2^{13})$

$$w_3 = \frac{DW_3}{DW_1 + DW_2 + DW_3} \tag{19}$$

where DW_1, DW_2 and DW_3 represent the impact difference of temperature, humidity and pressure, respectively, that is:

$$DW_1 = \left| \sum_{i=1,2,3,4} \sum_{j=1}^{128} p(O_j/i) - \sum_{i=5,6,7,8} \sum_{j=1}^{128} p(O_j/i) \right| \tag{20}$$

$$DW_2 = \left| \sum_{i=3,4,5,6} \sum_{j=1}^{128} p(O_j/i) - \sum_{i=1,2,7,8} \sum_{j=1}^{128} p(O_j/i) \right| \tag{21}$$

$$DW_3 = \left| \sum_{i=2,4,5,7} \sum_{j=1}^{128} p(O_j/i) - \sum_{i=1,3,6,8} \sum_{j=1}^{128} p(O_j/i) \right| \tag{22}$$

Here, (20)–(22) are consistent with the categories in Table 1. As we can see, the greater the impact the of temperature on the freshness, the larger DW_1 will be; this is also so for DW_2 and DW_3.

After obtaining $C(E_{sensing|j|i}, E_{best|j|i})$ using (16)–(22), we can assess the freshness of fruit deliveries using $f = \sum C(E_{sensing/j/i}, E_{best/j/i})$, where i and j depend on the actual delivery situation. As we can see, the smaller $C(E_{sensing|j|i}, E_{best|j|i})$, the closer $E_{sensing|j|i}$ is to $E_{best|j|i}$ and the fresher the in-transit fruits.

4. Numerical simulations

In this section, we use numerical experiments to demonstrate the efficiency and advantages of applying our two-stage approach to assessing the freshness of in-transit fruits in an IOT-based framework.

4.1. Effectiveness analysis of our scenario construction method

As mentioned in 3.2, there are three kinds of scenario construction methods: (1) the two-stage method considering Fruit and Operation situations in an IOT-based monitoring framework (IOT-based FO method, for short), (2) the full method considering Fruit, Operation, Environment and Time situations in an IOT-based monitoring framework (IOT-based FOET method, for short), and (3) the full situation method in traditional fruit commerce delivery (Traditional FOET method, for short). Table 2 compares the three scenario construction methods.

From the comparison in Table 2, we can see that the IOT-based FO method has greatly reduced complexity, which could consequently increase the efficiency of constructing the freshness assessment scenarios. The question is then how effective is the IOT-based FO method? To answer this question, we implemented Monte Carlo simulations in Matlab using the "learning-by-doing" mechanism described in Section 3.2.

In the simulations, we create the following settings: (i) The occurrence probabilities of the scenarios for the three methods similarly obey a normal distribution whose range is consistent with the number of scenarios. Taking the IOT-based FO method as an example, there are 1024 scenarios. We first label these scenarios from 1 to 1024 and assume that scenarios 512 and 513 have the maximal occurrence probability. (ii) The temperature, humidity and pressure in the most suitable environment obey the following normal distributions: $N(3, 0.8^2)$, $N(0.8, 0.05^2)$ and $N(6000, 1000^2)$, respectively. (iii) The stopping criterion is set to $Max_t = 1000$.

Using the above settings, we obtained the simulated environments produced by the three scenario construction methods. Based on Fig. 5, we can observe:

(1) With increasing learning times, all three scenario construction methods approached the most suitable environment. This consistency verified the effectiveness of our IOT-based FO method. In other words, our IOT-based FO method achieves an equivalent level of effectiveness using a greatly reduced number of scenarios. Thus, our IOT-based FO method has advantages over the IOT-based FOET method and the traditional FOET method.
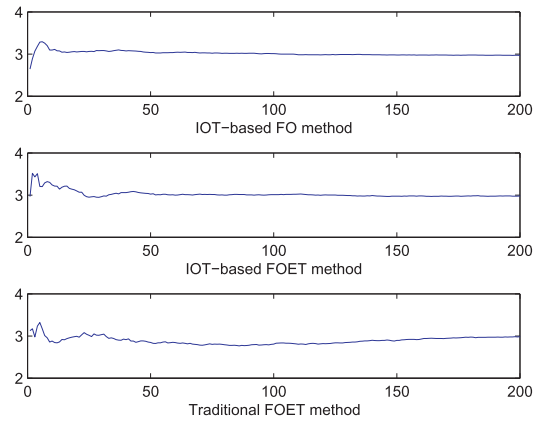
(a) Simulated temperature $\max\limits_{i=1,\ldots,8,j=1,\ldots,128}\{Temp_{best/j/i}\}$ where the x-coordinate expresses the learning time and the y-coordinate expresses the simulated temperature
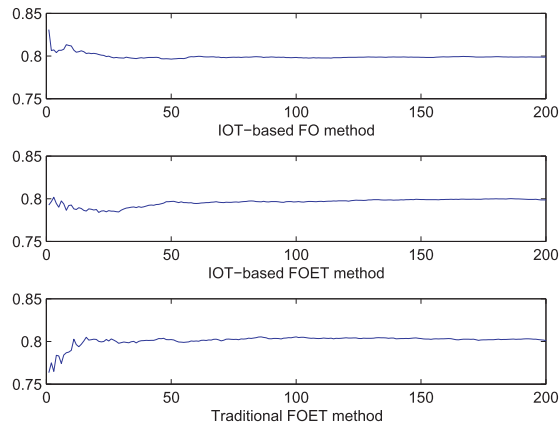
(b) Simulated humidity $\max\limits_{i=1,\ldots,8,j=1,\ldots,128}\{Humi_{best/j/i}\}$ where the x-coordinate expresses the learning time and the y-coordinate expresses the simulated humidity
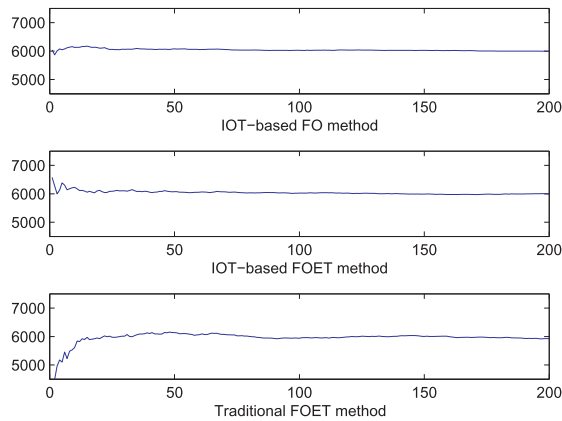
(c) Simulated pressure $\max\limits_{i=1,\ldots,8,j=1,\ldots,128}\{Pres_{best/j/i}\}$ where the x-coordinate expresses the learning time and the y-coordinate expresses the simulated pressure

Fig. 5. Simulated environment by the three kinds of scenario construction methods.

Table 3
Sensing data and assessment results when $\gamma = 0.5$.

Delivery No	Sensing environments			Assessment
	$\bar{Temp}_{sensing/64/4}$	$\bar{Humi}_{sensing/64/4}$	$\bar{Pres}_{sensing/64/4}$	results
1	[2.60, 2.95]	[0.75, 0.85]	[5800, 6100]	0.1861
2	[2.55, 2.90]	[0.75, 0.85]	[5800, 6100]	0.2003
3	[2.55, 2.90]	[0.70, 0.80]	[5800, 6100]	0.2161

(2) The simulated temperature, humidity and pressure values using the IOT-based FO method exhibited the smallest fluctuations. The traditional FOET method simulated environments with the largest fluctuations, especially at the beginning of the learning period. This results from the varying numbers of scenarios constructed using the three methods.

In short, the IOT-based FO method outperforms both the IOT-based FOET method and the traditional FOET method in terms of efficiency and stability, with equivalent effectiveness.

4.2. Freshness assessment using our scenario-based approach

In Section 4.1, we obtained the most suitable environment for each scenario $E_{best/j/i} = \{Temp_{best/j/i}, Humi_{best/j/i}, Pres_{best/j/i}\}$, as well as the probabilities $p(F_i)$ and $p(O_j/i)$. Then, we can use these learning rules to assess the freshness of in-transit fruits. As there are 1024 scenarios, it is impossible to illustrate the assessment using every scenario. Here, we select the following scenario as an example:

$$E_{best/64/4} = \{Temp_{best/64/4}, Humi_{best/64/4}, Pres_{best/64/4}\}$$
$$= \{2.989, 0.801, 6006.647\}$$

Then, given the three sensing delivery data points shown in Table 3, we can obtain the assessment results.
Here, we use the first set of sensing environment data to provide a detailed example. For the sensing environment data:

$$\bar{Temp}_{sensing/64/4} = [2.60, 2.95]$$

$$\bar{Humi}_{sensing/64/4} = [0.75, 0.85]$$

$$\bar{Pres}_{sensing/64/4} = [5800, 6100]$$

we use (13)–(15) to compare the interval sensing environment with the crisp best environment (here, $\gamma = 0.5$):

$$\delta(Temp_{best/64/4}, \bar{Temp}_{sensing/64/4}) = \frac{2.989 - (0.5 \times 2.60 + 0.5 \times 2.95)}{\frac{1}{2}(2.95 - 2.60) + 1} = 0.1821$$

$$\delta(Humi_{best/64/4}, \bar{Humi}_{sensing/64/4}) = \frac{0.801 - (0.5 \times 0.75 + 0.5 \times 0.85)}{\frac{1}{2}(0.85 - 0.75) + 1} = 0.00095$$

$$\delta(Pres_{best/64/4}, \bar{Pres}_{sensing/64/4}) = \frac{6006.647 - (0.5 \times 5800 + 0.5 \times 6100)}{\frac{1}{2}(6100 - 5800) + 1} = 0.3751$$

Then, we can calculate the distance between $E_{sensing/64/4}$ and $E_{best/64/4}$:

$$C(E_{sensing/64/4}, E_{best/64/4}) = \frac{1}{3} \times |0.1821| + \frac{1}{3} \times |0.00095| + \frac{1}{3} \times |0.3751| = 0.1861$$

where we consider approximately $w_1 = w_2 = w_3$ because the occurrence probabilities of the scenarios have normal distributions.

Similarly, we can obtain assessment results for the first set of sensing environment data using varying degrees of optimism, as Fig. 6 shows. Fig. 7 presents the assessment results for all sets of sensing environment data with varying levels of optimism.

Comparing the results in Table 3 and Figs. 6– 7 yields the following observations:

(1) When the degree of optimism is held at $\gamma = 0.5$ in Table 3, the fruits in the first sensing environment (that is, {[2.60, 2.95], [0.75, 0.85], [5800, 6100]}) are assessed as the freshest of the three environments, as its sensing environment approximates the best environment {2.989, 0.801, 6006.647} compared to the other two sensing environments (that is, {[2.55, 2.90], [0.75, 0.85], [5800, 6100]} and {[2.55, 2.90], [0.70, 0.80], [5800, 6100]}). These results verify the effectiveness of our interval comparison method in fruit freshness assessment.
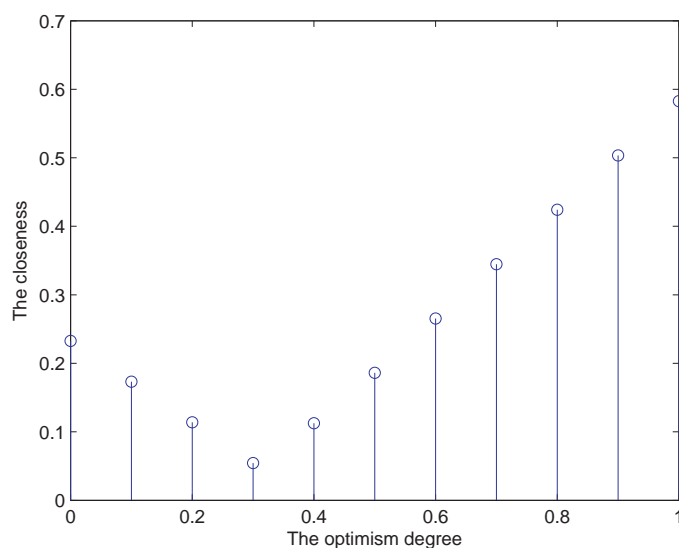
Fig. 6. The impact of the degree of optimism on the assessment results for the first set of sensing data, where the x-coordinate expresses the optimism degree and the y-coordinate expresses the closeness.
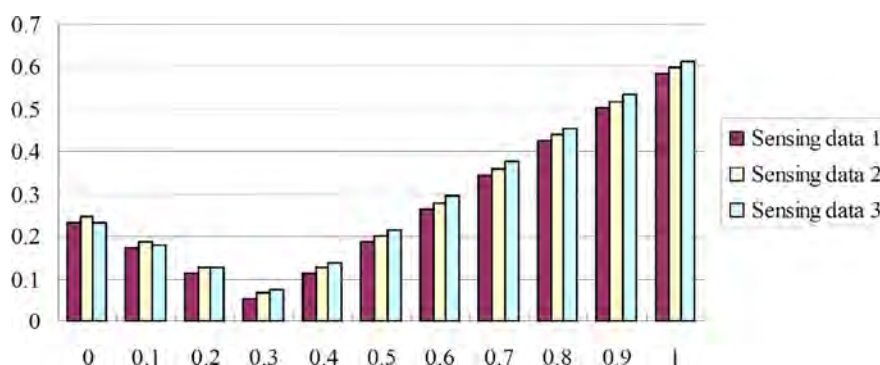
Fig. 7. The impact of the degree of optimism on the assessment results of all sets of sensing data, where the x-coordinate expresses the optimism degree and the y-coordinate expresses the closeness.

(2) For a given set of sensing environment data, the degree of optimism affects the comparison of the crisp best environment with the interval sensing environment, which consequently impacts the assessment results. As Figs. 6 and 7 show, every sensing environment is assessed with the smallest value when $\gamma = 0.3$.

From the results in Sections 4.1 and 4.2, we observe that the combination of scenario analysis and our interval comparison technique is effective for assessing the freshness of in-transit fruits under interval conditions. In fact, the integrated method can also be used to address other assessment and prediction problems in complicated and uncertain scenarios.

5. Concluding remarks

In this work, we investigated the monitoring and assessment of fruit freshness in e-fulfillment. For the monitoring aspect, we provided a comparison of the traditional fruit retailing and e-retailing transportation processes and applied IOT-related technologies, such as GPS, RFID sensor tagging and wireless sensor networks, to formulate a monitoring framework for e-commerce fruit delivery. For the fruit freshness assessment, we presented a two-stage scenario-based approach for assessing the freshness of in-transit fruits. This approach yielded the most suitable environment in each scenario and the occurrence probability of each scenario from the practical delivery operations. Freshness was assessed by comparing the similarity of the sensing environment to the most suitable environment for each scenario.

Although the effectiveness and advantages of our contributions are verified by numerical experiments, further work is required to produce practical benefits and extend the application fields. One such project might collect practical e-fulfillment data for fresh fruits to establish the most suitable environment for each scenario.

Acknowledgments

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712100

579

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O

[1]

[2]

[3]

"   "

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"

"   [5]

[6]

[7-8]

[9-10]   [11-12]

[13-14]   [15-16]

"　　"

$$\eta \quad \xi$$
$$\boldsymbol{B} \quad \boldsymbol{\Gamma} \quad \boldsymbol{\eta} \quad \boldsymbol{\xi} \qquad\qquad \zeta$$
[27-28]

[17]   1. 2

2013   7   9

[18]

[19]   610

579

94.9%

[20]

[21]

1=   2=

[22]   [23]   [24]   Probit   3=   4=   5=

Logistic

[25]   1

Probit   Logistic   Table 1   Statistical results of farmers' willingness to quit land
contract right

Willingness of quitting land	Frequency	Percent/%	Cumulative Percent/%
Quite unwilling	142	24.5	24.5
Unwilling	216	37.3	61.8
No matter	81	14	75.8
Willing	90	15.5	91.3
Quite willing	50	8.7	100
Total	579	100	-

1   "

"   142

24.5%   1/4

"   "   216

37.3%   2

61.8%

81   14%   "

"   90

15.5%   "   "   50

8.7%

1

1. 1

structural equation modeling,

SEM

1. 3

[26]

structural equation

measurement equation

$$x = A_x \cdot \xi + \delta \qquad\qquad 1$$
$$y = A_y \cdot \eta + \varepsilon \qquad\qquad 2$$

x y

δ ε x y A_x A_y

ξ η

$$\boldsymbol{\eta} = \boldsymbol{B\eta} + \boldsymbol{\Gamma\xi} + \zeta \qquad\qquad 3$$

4   3

19

Table 2   Rotated component matrix

	1 Principle component 1	2 Principle component 2	3 Principle component 3
Per capita income	0.894	-0.034	-0.001
Total income	0.875	-0.033	0.030
Education degree of householder	0.849	0.055	-0.014
Distance to nearest town	-0.812	0.027	0.036
Whether non-agricultural training is necessary	0.022	0.914	-0.116
Whether insurance could guarantee future life	0.018	0.807	-0.030
I consider I have the land contractual right	-0.023	0.804	-0.071
I consider that quitting land is a good thing	0.049	-0.772	0.027
Arable land area	0.003	-0.010	0.974
Agricultural income	0.006	-0.011	0.973
Amount of labor	-0.019	-0.134	0.545

Kaiser

4

Note: Principle components analysis was used as the extraction method; Orthogonal rotation method with Kaiser standardized was used and converged after four time iterations.

SPSS21

KMO   Kaiser-Meyer-Olkin
Bartlett   KMO=0.668   Bartlett

Kaiser

4   0.5
0.5
11   3
71.96%   2

3
per capita income
PI   total income   TI
education degree   ED
distance   D   4
labour   L
land area   LA   agricultural
income   AI   3
behavior awareness   BA
property awareness   PA   skill
awareness   SA   welfare awareness   WA

3
Table 3   Influence factors of farmers' willingness to quit land contract right

Latent variables	Observed variables	Explanation or questions setting						
Household family features	PI	/						
	TI	/						
	ED	0=	6=	9=	12=	16=		
	D	/km						
Household produce features	L							
	LA	/hm²						
	AI	/						
Household awareness features	BA	3= 4= 5=	"	"	1=	2=		
	PA	"	"	1=	0=			
	SA	"	"	1=	0=			
	WA	"	"	1=	0=			

1. 4

[27]

3

2

2 1

4

4

3   1   8 480

1

900   415 000   31 000

8.3 a

3.4

61 km

42.5

0.2 hm²   4.4 hm²   0.868 hm²

3.6   5 780   2

138

28.83%   181

31.26%   39.91%

467

80.66%   463

79.97%

405   69.95%

4

Note: PI denotes per capita income of household; D denotes distance to the nearest town; TI denotes total income; ED denotes education degree of householder; AI denotes agricultural income; L denotes amount of labor force; LA denotes arable land area; SA denotes skill awareness; WA denotes welfare awareness; BA denotes behaviour awareness; PA denotes property awareness; e1-e11 denote error variables of corresponding variables in structural equation model; Value 1 indicates the path coefficients are fixed as 1. The same as below.

1

Fig.1   Theoretical model of structural equation

4

Table 4   Descriptive statistics of main variables in model

Variables	Per capita income /	Total income/	Education degree/a	Distance /km	Labour	Land area /hm²	AI /	Behavior awareness	Property awareness	Skill awareness	Welfare awareness
Minimum	0.02	0.09	0	0	1	0.2	0.11	1	0	0	0
Maximum	8.3	41.5	16	129.61	9	4.4	3	5	1	1	1
Means	0.848	3.143	8.297	61	3.58	0.868	0.578	2.89	0.81	0.8	0.7
Standard deviation	1.151	4.332	3.419	42.5	1.493	0.669	0.44	0.995	0.395	0.401	0.459

n = 579

Note: *n* = 579.

2.2

AMOS21

1   1

7

2
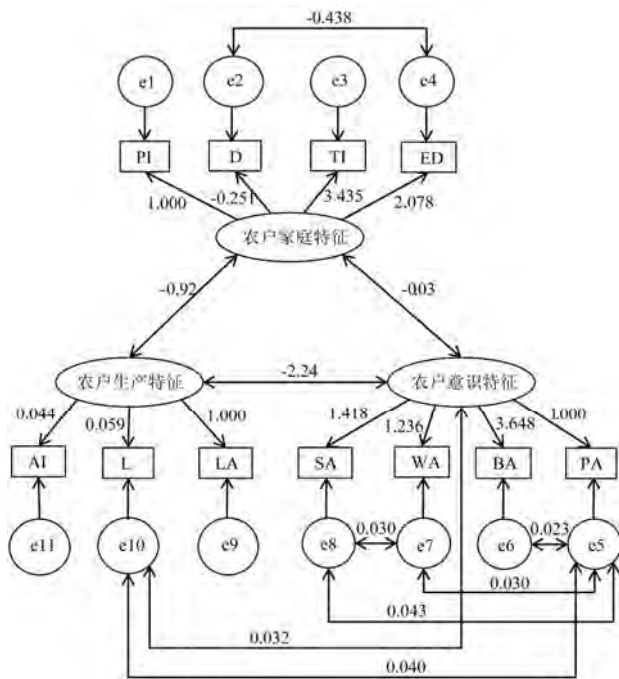
Note: Values denote the path coefficients.

2
Fig.2   Path coefficient of model

SEM

3

CMIN   Chi-square   P   0.05
        GFI   goodness of fit index   0.9
                          AGFI   adjust goodness of fit index
    0.9   RMSEA   root
mean square error of approximation   0.05
                                    IFI   incremental fit
index   0.9   TLI   Tucker-
Lewis   index   0.9   CFI
    comparative fit index   0.9
                                AIC   Akaike's information
criterion   AIC
        AIC
PNFI   parsimony-adjust normal index   0.5
                                        PCFI   parsimony-

adjust comparative index   0.5   [29]
        6   e2↔e4 e5↔e6 e5↔e7
e5↔e8   e5↔e10   e7↔e8   e10↔   7
                7   CMIN
                CMIN/DF   2
5

7

5
Table 5   Goodness of fit model

Model	Default model	Saturated model	Independence model
CMIN Chi-square	47.435	0	6 535.147
DF Degree freedom	34	0	55
P Probability	0.063		0
CMIN/DF Chi-square/ degree freedom	1.395		118.821
GFI Goodness of fit index	0.986	1	0.334
AGFI Adjust goodness of fit index	0.972		0.201
RMSEA Root mean square error of approximation	0.260		0.151
IFI Incremental fit index	0.998	1	0
TLI Tucker- Lewis index	0.997		0
CFI Comparative fit index	0.998	1	0
AIC Akaike's information criterion	111.435	132	6 557.147
PNFI Parsimony-adjust normal index	0.614	0	0
PCFI Parsimony- adjust comparative index	0.617	0	0

2.3

    6

                                6

                                                3

    0

    3

6
Table 6   Estimate results of covariance

Path	Covariance estimate	Standard error	Critical ration
↔	-0.917	0.479	-1.988
↔	-0.026	0.012	-2.171
↔	2.241**	0.189	11.846
e2↔e4	-0.438**	0.040	-10.936
e5↔e8	0.043**	0.004	10.381
e7↔e8	0.030**	0.004	7.067
e5↔e7	0.030**	0.005	5.771
e10↔	0.032**	0.007	4.643
e5↔e6	0.023**	0.006	3.601
e5↔e10	0.040	0.015	2.605

**   1%

Note: ** denotes significance at 1% level, the same as below.

e2↔e4

e5↔e8   e7↔e8   e5↔e7   3

e10↔

2

e5↔e6   e5↔e10

2

7

"   →
" "   →   " "   →
→   "

3

3

3

1   11

1%

7
Table 7   Regression Weights

Path	Estimate	Standard error	Critical ration
←	1.000		
←	-0.251**	0.013	-19.481
←	3.435**	0.103	33.192
←	2.078**	0.102	20.446
←	1.000		
←	3.648**	0.255	14.334
←	1.236**	0.087	14.270
←	1.418**	0.071	19.845
←	1.000		
←	0.059**	0.006	10.361
←	0.044**	0	194.811

3.435

62.8%

2.078

0.059   0.044

2

2

3

3.648

31 430

3

3

[   ]

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3

4

1   Logistic   Probit

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Analysis of influence factors of farmers' willingness to quit right of contractual and management of rural land in progress of urbanization

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Abstract: During the rapid progress of urbanization in China, the shortage of land resources have become a serious problem limiting the improvement of social economic development. A recognized better way and a key method to solve the land resource shortage problem, especially for the arable land, is to encourage farmers to quit the right of contract and management of rural land. This paper is based on the study framework of the farmers' willingness to quit the right of contract and management of rural land and the rural survey data of 579 households in Guanzhong, Shaanxi Province. The principal component analysis method and structural equation model are implemented in this the research. Firstly, the principal component analysis method is used to reduce the dimension of indicators. Eight indicators are excluded and eleven indicators are reserved to be utilized as the influence factors in the Structural Equation Model. All the eleven indicators are classified into three kinds of groups. They are household family features, household produce features and household awareness features. Secondly, the Structural Equation Model is applied to analyze the influence factors and the influence direction of farmers' willingness to quit the right of contract and management of rural land. The results are as follows: Four indicators in the group of household family characteristics, household per capita income, the distance from county, the total income of the family, and the education degree of the householder, affect the farmers' willingness to quit the right of contract and management of rural land positively. Three indicators in the group of household production characteristics, total agricultural income, farmland area and the number of labor in family, show a positive influence on farmers' willingness to quit the right of contract and management of rural land. Four indicators in the group of household awareness characteristics, the awareness of property right, the awareness of behavior, the awareness of welfare, and the awareness of nonagricultural skills, have a significant positive impact on farmers' willingness to quit the right of contract and management of rural land. It could be concluded that famers' willingness to quit the right of contract and management of rural land is affected by a variety of factors and that all of the influencing factors have a covariance relationship with each other. The meaning of analyzing the influence factors of farmers' willingness to quit the right of contract and management of rural land could provide a reference for the development of reasonable rural land quitting policies and mechanisms.

Key words: land use; models; zoning; land management; urbanization; quitting willingness of the right of contractual and management of rural land; influence factors; structural equation model

[1], [2+]

(1.   ,   712100;2.   ,   100191)

:   ,   ,
                    ,   。   NP-Hard   ,
                                        。   , $L_{max}+1$,
                                ,   。

:   ;   ;   ;

:F406. 2   :A

Integrated optimization of order assignment and joint production-transportation scheduling with commit-to-delivery mode

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Abstracts: Aiming at the make-to-order enterprises with commit-to-delivery, the existing researches were expanded to multi-plant layout to investigate the integrated scheduling of order assignment and production-delivery, which could minimize the total costs of production and transportation. The analysis result showed the computing complexity of NP-Hard for this problem, and a three-steps heuristics method of polynomial time complexity was proposed. The result indicated that the worst case performance of this method was bounded by $L_{max}+1$, and the near-optimal solution would generate and the tight bounds would obtain by this method.

Key words: commit-to-delivery; make-to-order; integrated optimization; heuristic method

0   ,   (Make to Or-
der, MTO)   ,   ,

        ,   ,   。

        ,Dornier   ,   53%   ,
                        [1]。   ,   (Delivery Lead Time, DLT)   ,
            ,   ,
                :①   。   ,
;②   。
            ,   。   ,   ,   、   `   。
                        ,   ,

（Commit to Ship，CTS）

[3-4]

（Commit to Delivery，CTD）

Chen，Wang　　Hall

[5-7]

[2]，　　　　　　　　　　、Cemex

MEI　　　　　　　　　　　　　　　　　　　[8-10]

，Chen

[10]

Stecke　　Zhao（　　　S&Z-H），Melo　　Zhong

[2,11-12]。S&Z-H

:①

;②

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[2]。Melo　　　　　S&Z-H

:①

;②

[11]。Zhong　　　　　　S&Z-H

$2^{[12]}$。

[2]，

，Chen

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1.1

（1）

N ， $i \in N, N = \{1, 2, \cdots, n\}$；

Q_i i ， $0 < Q_i \leqslant C_j, j \in M, i \in N$；

d_i i ， $d_i \geqslant 2$， $d_{\max} = \max\limits_{i \in N}\{d_i\}$；

f_i i ；

r_i i ；

M ， $j \in M, M = \{1, 2, \cdots, m\}$， ， $n > m$；

C_j j ；

c_j j ；

f_{jl} j l ；

$P_{ij}(Q_i)$ i j ；

$G_{ij}(Q_i, r_i)$ i j 。

（2）

1) 。

2)

， 。

3) 。

4) ，

， ，

，

$$G_{ij}(Q_i, r_i) = Q_i(\alpha_j - \beta_j r_i), \alpha_j > 0, \beta_j > 0 。$$

， ，

[2] 。

α_j, β_j

$$\alpha_j - \beta_j(d_{\max} - 1) > 0, \tag{1}$$

（1） ，

。

（5）

，

：

$$\sum_{i \in A_k} Q_i \leqslant k \sum_j C_j, A_k = \{i \mid d_i \leqslant k + 1, i \in N\},$$
$$k = 1, 2, \cdots, d_{\max} - 1 。 \tag{2}$$

1.2

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（1） ，

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（2） ， ，

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， ，

， β_j，

，

，

$$r_i = d_i - [f_i] 。 \tag{3}$$

， P，

：

$$\min \sum_i \sum_j [P_{ij}(Q_i) + G_{ij}(Q_i, r_i)] 。$$

$P_{ij}(Q_i) = c_j Q_i, G_{ij}(Q_i, r_i) = Q_i(\alpha_j - \beta_j r_i)$，

P ：

$$(P) \quad \min \sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i[\alpha_j - \beta_j(d_i - [f_i])]\} 。$$

$$\text{s. t.} \quad \sum_j \sum_l Y_{ijl} = 1; \tag{4}$$

$$\sum_i Y_{ijl} \leqslant 1; \qquad (5)$$

$$f_i = \sum_j \sum_l Y_{ijl} f_{jl}; \qquad (6)$$

$$f_{jl} = f_{j,l+1} + \frac{\sum_i Y_{ijl} Q_i}{C_j}; \qquad (7)$$

$$Y_{ijl} = \begin{cases} 1, & i \qquad j \\ & l \qquad ; \\ 0, & \end{cases}$$

$$:i \in N, j \in M, l \in N_\circ$$

，   （4）   （5）

；   （6）   （7）

，

，   。   ， P

2

P ，

P 。

2. 1   NP-Hard

P ，   ：

1 P NP-Hard

P， $m=1$ ， P

， P'。S&Z-H

，

NP-Hard   [2]。 P'

，

P'， P' NP-Hard   ，

Pinedo

[13]   ， P NP-Hard   。   。

2. 2

P NP-Hard   ，

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；   ，   ，

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， P

；   ，   ，

H-3。

（1）

SOS(smallest order size)

SOS   ， $\{[1],[2],\cdots,$
$[i],\cdots,[n]\}$。 Δ_{ih} SOS $[i+h]$
$[i]$ ，$h=1,2,\cdots,n-1$，

$$\Delta_{ih} = Q_{[i+h]} - Q_{[i]}, i = 1,2,\cdots,n-h_\circ \quad (8)$$

，$\Delta_{ih} \geqslant 0$。

（2）

P_1 ：

$(P_1) \quad \min \sum_i \sum_j \sum_l Y_{[i]jl}[c_j Q_{[i]} + Q_{[i]}\alpha_j -$

$$Q_{[i]}\beta_j d_{[i]} + \beta_j \frac{Q_{[i]}}{C_j}(lQ_{[i]} + \sum_{h=1}^{l-1}\Delta_{ih})]_\circ$$

s. t. $$\sum_j \sum_l Y_{[i]jl} = 1;$$

$$\sum_i Y_{[i]jl} \leqslant 1;$$

$$Y_{[i]jl} = \begin{cases} 1, & [i] \qquad j \\ & l \qquad ; \\ 0, & \end{cases}$$

$$:i \in N, j \in M, l \in N_\circ$$

P_1 P_1^r， P_1^r
（Totally Unimodular，TU），
， P_1^r
， P_1 ， P_1
π_1， π_1^a，$\pi_1^a = \{X_{ij}\}$，
$i \in N, j \in M$， $X_{ij} = 1$， i
j ； $X_{ij} = 0$。

P_1 π_1，
$P_1(\pi_1)$，   ：

2 $P_1(\pi_1) = P_1(\pi_1^a, SOS)$， π_1^a
，   SOS。

π_1^a j $[i_1]$，
$[i_2] \in N, Q_{[i_1]} > Q_{[i_2]}$，   SOS，
， $[i_1],[i_2]$ j
$l+1$ l 。

P_1 ，
（9）   。

$$\beta_j \frac{Q_{[i]}}{C_j}(lQ_{[i]} + \sum_{h=1}^{l-1}\Delta_{ih})_\circ \qquad (9)$$

$[i_1],[i_2]$ (9)

$$Con_{\text{NONE-SOS}} = \beta_j \frac{Q_{[i_1]}}{C_j}[(l+1)Q_{[i_1]} +$$

$$\sum_{h=1}^{l}\Delta_{i_1 h}] + \beta_j \frac{Q_{[i_2]}}{C_j}(lQ_{[i_2]} + \sum_{h=1}^{l-1}\Delta_{i_2 h})。$$

$[i_1],[i_2]$ SOS

，$[i_1],[i_2]$ j l

$l+1$ ， $[i_1],[i_2]$ (9)   :

$$Con_{\text{SOS}} = \beta_j \frac{Q_{[i_1]}}{C_j}(lQ_{[i_1]} + \sum_{h=1}^{l-1}\Delta_{i_1 h}) +$$

$$\beta_j \frac{Q_{[i_2]}}{C_j}[(l+1)Q_{[i_2]} + \sum_{h=1}^{l}\Delta_{i_2 h}],$$

$$Con_{\text{SOS}} - Con_{\text{NONE-SOS}} = \beta_j \frac{Q_{[i_1]}}{C_j}(-Q_{[i_1]} - \Delta_{i_1 l}) + \beta_j$$

$$\frac{Q_{[i_2]}}{C_j}(Q_{[i_2]} + \Delta_{i_2 l}) = \frac{\beta_j}{C_j}(-Q_{[i_1]}Q_{[i_1+l]} + Q_{[i_2]}Q_{[i_2+l]})。$$

    $Q_{[i_1]} > Q_{[i_2]}$ ， $Q_{[i_1+l]} \geqslant Q_{[i_2+l]}$ ，

$Con_{\text{SOS}} - Con_{\text{NONE-SOS}} < 0$ ， π_1^a j

    SOS P_1 ，   ，

         ， π_1^a

         SOS， $P_1(\pi_1)$

$= P_1(\pi_1^a, \text{SOS})$ 。   。

（2）

              π_1^a

    P ， P

         ，   ，

           。   ，

S&Z-H   ，

          。

   π_1^a ， j s_j

，s_j^0 EDD-LOS(earliest due date-

largest order size)   。EDD-

LOS   ，

         ，

       。

       ，   :

$$k_j = \lceil \frac{\sum_i X_{ij}Q_i}{C_j} \rceil, X_{ij} \in \pi_1^a, j \in M, k_j \quad \pi_1^a$$

j (d)；

    O_{jk} s_j k d   ， $k+1$

d   ；

    O_{jk} s_j k d k d

       ；

$Q_{jk,l}^O$ O_{jk} k d   ，

$k=1,2,\cdots,k_j-1$；

$Q_{jk,r}^O$ O_{jk} $k+1$ d

，$k=1,2,\cdots,k_j-1$；

        s_j ， O_{jk} ， $Q_{jk,l}^O$ ，

$Q_{jk,r}^O$ 0； O_{jk} ， O_{jk} k d

  $k+1$ d   ，   ， $Q_{jk,l}^O + Q_{jk,r}^O =$

$Q_{O_{jk}}$ ， O_{jk} $k+1$ d

     。

        P ，   S & Z-H   :

     1 π_1^a ， j ， s_j^0

， $s_j = s_j^0, k = k_j - 1$ 。

     2 $k = 0$ ，   ， s_j

j ， (π_1^a, s_j) P ；

   s_j ，

（1） O_{jk} ， $k = k-1$ ，   2。

（2） O_{jk} ， $i \in O_{jk+1}$:

   1） i $Q_i \leqslant Q_{jk,l}^O$ ， $k = k-1$ ，

    2。

   2） i $Q_i \leqslant Q_{jk,l}^O$ ， $Q_{i'} = \max\{Q_i$

$\leqslant Q_{jk,l}^O \mid i \in O_{jk+1}\}$ ， i' O_{jk}

， s_j ，   2。

     S & Z-H   ，

        [2]。 P, S & Z-H

        :

     ， P

$$\min \sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i[\alpha_j - \beta_j(d_i - \lceil f_i \rceil)]\}。$$

     ， π_1^a ，

$$\min \sum_i \sum_j X_{ij}Q_i \beta_j \lceil f_i \rceil, X_{ij} \in \pi_1^a, \quad Q_{jk}$$

j k d

，

$$\min \sum_j \beta_j \sum_{k=1}^{k_j} Q_{jk} \times k。 \quad (10)$$

$$Q_{jk} = \begin{cases} C_j + Q_{jk-1,l}^O - Q_{jk,l}^O, & k = 2,\cdots,k_j-1; \\ C_j - Q_{j1,l}^O, & k = 1; \\ C_j + Q_{jk_j-1,l}^O - (k_j C_j - \\ \quad \sum_i X_{ij}Q_i), & k = k_j。 \end{cases}$$

     (10)   ，

$$\min \sum_j \beta_j \lceil \frac{k_j(1+k_j)}{2}C_j - (k_j C_j -$$

$$\sum_i X_{ij}Q_i) + \sum_{k=1}^{k_j-1} Q_{jk,l}^O \Big], X_{ij} \in \pi_1^a,$$

， $\min\sum_j$

$$\beta_j \sum_{k=1}^{k_j-1} Q_{jk,l}^O 。$$

S&Z-H   ，

O_{jk} $Q_{jk,l}^O$ 。

3

P π, π

S&Z-H   [2]：

3   (2), j

，EDD-LPT   ，EDD-LPT

H-3   ：

， π_1^a

，   S&Z-H

， s_j^0

EDD-LOS

LOS   LPT   。   ， j ，

EDD-LOS

，   EDD-LOS，

，   Chen

[10]。

H-3   ，   ：

4   H-3

H-3   ：

(1) Δ_{ih}，

$O(n\log n)$，

$O(n^2)$。

(2)   ，

，   。

(3)   S&Z-H s_j^0

（右欄）

， $\sum_j (k_j-1)(L_j-1)$,

L_j π_1^a j 。 i

$\in N, j \in M,$ $0 < Q_i \leqslant C_j,$ $k_j \leqslant L_j,$ $\sum_j (k_j$

$-1)(L_j-1) \leqslant \sum_j (L_j-1)^2 \leqslant \Big[\sum_j (L_j-1)\Big]^2 =$

$(n-m)^2,$ $O(n^2)$。

，H-3

。

4

P π_*,

$\pi_*^a,$ $P(\pi_*)$。   2

， P_1 π_1,

$\pi_1^a,$ $P_1(\pi_1)$。

H-3   ， P

。

4.1

1 P_2

(P_2) $\min \sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i +$

$Q_i[\alpha_j - \beta_j(d_i - f_i)]\}$,

P ， π_2,

$P_2(\pi_2)$,

(1) P_2

，   。

(2) P_2 QSAP(quadratic semi-assign-

ment problem)。

(3) $P(\pi_*) \geqslant P_2(\pi_2)$。

(1) P_2,   ：

(P_2) $\min \sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i +$

$Q_i[\alpha_j - \beta_j(d_i - f_i)]\}$。

s.t. $\sum_j \sum_l Y_{ijl} = 1$;

$$\sum_i Y_{ijl} \leqslant 1;$$

$$f_i = \sum_j \sum_l Y_{ijl} f_{jl};$$

$$f_{jl} = f_{j,l+1} + \frac{\sum_i Y_{ijl} Q_i}{C_j};$$

$$Y_{ijl} = \begin{cases} 1, & i \quad\quad j \\ & l \quad\quad ; \\ 0, & 。 \end{cases}$$

$:i\in N,j\in M,l\in N, \quad f_{jo}=0$。

$$\sum_i\sum_j\sum_l Y_{ijl}Q_i(c_j+\alpha_j-\beta_j d_i)+$$
$$\sum_i\sum_j\sum_l Y_{ijl}Q_i\beta_j f_i。 \qquad (11)$$

，(11)   ，

$$\sum_i\sum_j\sum_l Y_{ijl}Q_i\beta_j f_i=\sum_j\beta_j\sum_i\sum_l Y_{ijl}$$

$Q_i f_i$, j, P_2

$1\parallel\sum_i w_i C_i$,

WSPT（weighted shortest process time

first）[13]， $\dfrac{Q_i}{Q_i/C_j}$ ，

j ，$\dfrac{Q_i}{Q_i/C_j}$ 。   ，

j ，   （11）   ，

（11）   ，

       。

       ， P_2

，

（2） j

       ，   （11）   :

$$\sum_i\sum_j\sum_l Y_{ijl}Q_i\beta_j f_i=\sum_j\sum_i\sum_l Y_{ijl}\beta_j$$
$$\frac{Q_i}{C_j}\left(Q_i+\sum_{i'=1}^n\sum_{l'=1}^{l-1}Y_{i'jl'}Q_{i'}\right)。 \qquad (12)$$

（1）   ， P_2

，   。（12），

$$\sum_i\sum_j X_{ij}Q_i(c_j+\alpha_j-\beta_j d_i)+$$
$$\sum_j\sum_i X_{ij}\frac{\beta_j}{2C_j}\left(Q_i^2+Q_i\sum_{i'=1}^n X_{i'j}Q_{i'}\right),$$

$$\sum_i\sum_j X_{ij}Q_i(c_j+\alpha_j-\beta_j d_i)+$$
$$\sum_j\frac{\beta_j}{2C_j}\sum_i X_{ij}Q_i^2+\sum_j\frac{\beta_j}{2C_j}\left(\sum_i X_{ij}Q_i\right)^2。 (13)$$

（13）

$$\boldsymbol{X}^T\boldsymbol{B}+\frac{1}{2}\boldsymbol{X}^T\boldsymbol{A}\boldsymbol{X}。$$

:

$$\boldsymbol{X}^T=\underbrace{(X_{11}X_{21}\cdots X_{n1}X_{12}\cdots X_{n2}\cdots X_{1j}\cdots X_{nj}\cdots X_{1m}\cdots X_{nm})}_{n\times m};$$

$$\boldsymbol{B}^T=\underbrace{(c_1+\alpha_1-\beta_1 d_1\cdots c_1+\alpha_1-\beta_1 d_n\cdots c_j+\alpha_j-\beta_j d_1\cdots c_j+\alpha_j-\beta_j d_n\cdots c_m+\alpha_m-\beta_m d_1\cdots c_m+\alpha_m-\beta_m d_n)}_{n\times m};$$

$$\boldsymbol{A}=\underbrace{\begin{pmatrix}
\dfrac{2\beta_1}{C_1}Q_1^2 & \dfrac{\beta_1}{C_1}Q_1 Q_2 & \cdots & \dfrac{\beta_1}{C_1}Q_1 Q_n & & & & & & & \\
\dfrac{\beta_1}{C_1}Q_2 Q_1 & \dfrac{2\beta_1}{C_1}Q_2^2 & & \vdots & & & & & & & \\
\vdots & & \ddots & & & & & & & & \\
\dfrac{\beta_1}{C_1}Q_n Q_1 & \cdots & & \dfrac{2\beta_1}{C_1}Q_n^2 & & & & & & & \\
& & & & \dfrac{2\beta_j}{C_j}Q_1^2 & \cdots & \dfrac{\beta_j}{C_j}Q_1 Q_n & & & & \\
& & & & \vdots & \ddots & \vdots & & & & \\
& & & & \dfrac{\beta_j}{C_j}Q_n Q_1 & \cdots & \dfrac{2\beta_j}{C_j}Q_n^2 & & & & \\
& & & & & & & \dfrac{2\beta_m}{C_m}Q_1^2 & \cdots & \dfrac{\beta_m}{C_m}Q_1 Q_n \\
& & & & & & & \vdots & \ddots & \vdots \\
& & & & & & & \dfrac{\beta_m}{C_m}Q_n Q_1 & \cdots & \dfrac{2\beta_m}{C_m}Q_n^2
\end{pmatrix}}_{n\times m}。$$

A 　$nm \times nm$ 　　　　　　，

m 　$n \times n$ 　　　　　　　　　0，

A 　k 　　　　　　　0，A 　　　　。

P_2

：

$$(P_2) \quad \min \boldsymbol{X}^{\mathrm{T}}\boldsymbol{B} + \frac{1}{2}\boldsymbol{X}^{\mathrm{T}}\boldsymbol{A}\boldsymbol{X} 。$$

s. t. 　　　$\sum_j X_{ij} = 1, i \in N$;

$$X_{ij} = \begin{cases} 1, & i \qquad j \\ 0, & 。 \end{cases}$$

$$i \in N, j \in M 。$$

，P_2 　　　　　QSAP,

QSAP 　NP-Hard 　　　，

　　，　　　　　　　　　　[14-16]。

　（3）　　P

$$\sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i [\alpha_j - \beta_j (d_i - [f_i])]\} 。$$

$$i \in N,$$
$$[f_i] \geqslant f_i 。 \qquad (14)$$

P_2

$$\sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i [\alpha_j - \beta_j (d_i - f_i)]\} 。$$

（14）　　，π 　　　P 　　　　，

$$P(\pi) \geqslant P_2(\pi) 。 \qquad (15)$$

　　　P 　　　　　π_*，　$P(\pi_*)$
$\geqslant P_2(\pi_*)$;

　　　　　P_2 　　　π_2，　$P_2(\pi_*) \geqslant$
$P_2(\pi_2)$。

　　　$P(\pi_*) \geqslant P_2(\pi_2)$。　　　。

　　　1　　，　$P(\pi_*) \geqslant P_2(\pi_2)$,
P_2 　　　　$P_2(\pi_2)$ 　$P(\pi_*)$ 　　，
P_2 　　　QSAP,

　　，　　　H-3 　　　　　P_2
P 　　　，　　P_1 。
$P(\pi_*)$ 　$P_1(\pi_1)$,　　　：
2　$P(\pi_*) \geqslant P_1(\pi_1)$。

　　（12）　，　　P_2

$$\sum_i \sum_j \sum_l Y_{ijl} Q_i (c_j + \alpha_j - \beta_j d_i) +$$
$$\sum_j \sum_i \sum_l Y_{ijl}\beta_j \frac{Q_i}{C_j}(Q_i + \sum_{i'=1}^n \sum_{l'=1}^{l-1} Y_{i'jl'}Q_{i'}) 。$$
　　1　　，P_2

　　　　，　　　　　。

π 　　　P_2 　　　，
π^a,

$$P_2(\pi) = P_2(\pi^a, \text{SOS}) 。 \qquad (16)$$
　　π^a 　　　　　，SOS

P_2 　　　。

$P_2(\pi^a, \text{SOS})$ 　　　SOS 　　　　　j

　　，　Δ_{ih} 　　（8）　$\sum_{h=1}^{l-1} \Delta_{ih}$

SOS 　　　，　　$[i]$ 　$l-1$

$[i]$ 　　　　　　。

$$P_2(\pi^a, \text{SOS}) = \sum_i \sum_j \sum_l Y_{ijl} Q_i (c_j + \alpha_j - \beta_j d_i) +$$
$$\sum_j \sum_i \sum_l Y_{ijl}\beta_j \frac{Q_i}{C_j}(Q_i + \sum_{i'=1}^n \sum_{l'=1}^{l-1} Y_{i'jl'}Q_{i'}) $$
$$= \sum_i \sum_j \sum_l Y_{ijl} Q_i (c_j + \alpha_j - \beta_j d_i) +$$
$$\sum_j \sum_i \sum_l Y_{ijl}\beta_j \frac{Q_i}{C_j}[lQ_i + \sum_{i'=1}^n \sum_{l'=1}^{l-1} Y_{i'jl'}(Q_{i'} - Q_i)]$$
$$\geqslant \sum_i \sum_j \sum_l Y_{[i]jl}[c_j Q_{[i]} + Q_{[i]}\alpha_j - Q_{[i]}\beta_j d_{[i]} +$$
$$\beta_j \frac{Q_{[i]}}{C_j}(lQ_{[i]} + \sum_{h=1}^{l-1} \Delta_{ih})], Y_{ijl}, Y_{[i]jl} \in (\pi^a, \text{SOS}),$$

$$P_2(\pi^a, \text{SOS}) \geqslant P_1(\pi^a, \text{SOS}) 。 \qquad (17)$$
　　（16）　　（17）　　，
$$P_2(\pi) \geqslant P_1(\pi^a, \text{SOS}), \qquad (18)$$
　　（18）　　$P(\pi) \geqslant P_1(\pi^a, \text{SOS})$,　　　　P
　　π_*,　$P(\pi_*) \geqslant P_1(\pi_*^a, \text{SOS})$,
P_1 　　　π_1,　$P_1(\pi_*^a, \text{SOS}) \geqslant P_1(\pi_1)$。
，$P(\pi_*) \geqslant P_1(\pi_1)$。　　　。

　　　2　　，H-3 　　　　　P_1
$P_1(\pi_1)$ 　$P(\pi_*)$ 　　　　。

4. 2

　　　2　　，H-3 　　　P 　　（π_1^a,
s_j），　　　　　$P(\pi_1^a, s_j)$，　　1
H-3 　　　　　　　。

　　1　L_j 　π_1^a 　　　　j 　　　，
$L_{\max} = \max_{j \in M}\{L_j\}$,　　$P(\pi_1^a, s_j) \leqslant (L_{\max}+1)P(\pi_*)$,
H-3 　　　　$L_{\max}+1$ 　　　。

　　　P

$$\sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i [\alpha_j - \beta_j (d_i - [f_i])]\} 。$$
　　P_2

$$\sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i[\alpha_j - \beta_j(d_i - f_i)]\}.$$

π 　　　 P 　　　 ， (15) $P(\pi) \geqslant P_2(\pi)$， $Y_{ijl} \in \pi$，

$$\sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i[\alpha_j - \beta_j(d_i - [f_i])]\}$$
$$= \sum_i \sum_j \sum_l Y_{ijl}\{c_j Q_i + Q_i[\alpha_j - \beta_j(d_i - f_i)]\} +$$
$$\sum_i \sum_j \sum_l Y_{ijl}[Q_i\beta_j([f_i] - f_i)].$$

i， $0 \leqslant [f_i] - f < 1$， $\beta_{max} = \max_{j \in M}\{\beta_j\}$，

$$P(\pi) < P_2(\pi) + \beta_{max}\sum_i Q_i. \quad (19)$$

(17) $P_2(\pi^a, SOS) \geqslant P_1(\pi^a, SOS)$，

$$P_2(\pi^a, SOS) = \sum_i \sum_j \sum_l Y_{[i]jl}\Big[c_j Q_{[i]} + Q_{[i]}\alpha_j -$$
$$Q_{[i]}\beta_j d_{[i]} + \beta_j \frac{Q_{[i]}}{C_j}\Big(lQ_{[i]} + \sum_{h=1}^{l-1}\Delta_{ih}\Big)\Big] +$$
$$\sum_j \sum_i \sum_l Y_{[i]jl}\beta_j \frac{Q_{[i]}}{C_j}\Big[\sum_{i'=1}^{n}\sum_{l'=1}^{l-1}Y_{[i']jl'} \cdot$$
$$(Q_{[i']} - Q_{[i]}) - \sum_{h=1}^{l-1}\Delta_{ih}\Big]$$
$$= P_1(\pi^a, SOS) + \sum_j \sum_i \sum_l Y_{[i]jl}\beta_j \frac{Q_{[i]}}{C_j}\Big[\sum_{i'=1}^{n}\sum_{l'=1}^{l-1}$$
$$Y_{[i']jl'}(Q_{[i']} - Q_{[i]}) - \sum_{h=1}^{l-1}\Delta_{ih}\Big], Y_{[i]jl} \in (\pi^a, SOS).$$

，

$$\sum_j \sum_i \sum_l Y_{[i]jl}\beta_j \frac{Q_{[i]}}{C_j}\Big[\sum_{i'=1}^{n}\sum_{l'=1}^{l-1}Y_{[i']jl'}(Q_{[i']} - Q_{[i]}) -$$
$$\sum_{h=1}^{l-1}\Delta_{ih}\Big] \leqslant \sum_j \sum_i \sum_l Y_{[i]jl}\beta_j \frac{Q_{[i]}}{C_j}$$
$$\Big[\sum_{h=n-i-l+2}^{n-i}\Delta_{ih} - \sum_{h=1}^{l-1}\Delta_{ih}\Big]. \quad (20)$$

$i \in N, j \in M$， $0 < Q_i \leqslant C_j$，

$$\sum_{h=n-i-l+2}^{n-i}\Delta_{ih} - \sum_{h=1}^{l-1}\Delta_{ih} \leqslant \sum_{h=n-i-l+2}^{n-i}\Delta_{ih} \leqslant (l-1)C_j. \quad (21)$$

(20) (21) ，

$$P_2(\pi^a, SOS) = P_1(\pi^a, SOS) + \sum_j \sum_i \sum_l$$
$$Y_{[i]jl}\beta_j \frac{Q_{[i]}}{C_j}\Big[\sum_{i'=1}^{n}\sum_{l'=1}^{l-1}Y_{[i']jl'}(Q_{[i']} - Q_{[i]}) - \sum_{h=1}^{l-1}\Delta_{ih}\Big]$$
$$\leqslant P_1(\pi^a, SOS) + \sum_j \sum_i \sum_l Y_{[i]jl}\beta_j Q_{[i]}(l-1),$$
$$Y_{[i]jl} \in (\pi^a, SOS).$$

L'_j π^a 　　　 j 　　　 ， $L'_{max} = \max_{j \in M}\{L'_j\}$， $\sum_j \sum_i \sum_l Y_{[i]jl}\beta_j Q_{[i]}(l-1) < \beta_{max}(L'_{max} - 1)\sum_i Q_i$。

$$P_2(\pi^a, SOS) \leqslant P_1(\pi^a, SOS) + \beta_{max}(L'_{max} - 1)\sum_i Q_i. \quad (22)$$

(16)， (19) (22) ，

$$P(\pi) \leqslant P_1(\pi^a, SOS) + \beta_{max}(L'_{max} - 1) \cdot \sum_i Q_i + \beta_{max}\sum_i Q_i$$
$$= P_1(\pi^a, SOS) + \beta_{max}L'_{max}\sum_i Q_i. \quad (23)$$

H-3 　　　 P 　　 $(\pi_1^a, s_j), L_j$ 　 π_1^a 　 j 　　 ， $L_{max} = \max_{j \in M}\{L_j\}$，(23)

$$P(\pi_1^a, s_j) \leqslant P_1(\pi_1^a, SOS) + \beta_{max}L_{max}\sum_i Q_i.$$

2 　　 $P(\pi_*) \geqslant P_1(\pi_1)$， $\dfrac{P(\pi_1^a, s_j)}{P(\pi_*)}$
$$\leqslant \frac{P_1(\pi_1^a, SOS) + \beta_{max}L_{max}\sum_i Q_i}{P_1(\pi_1)}. \quad 2 ，$$
$P_1(\pi_1) = P_1(\pi_1^a, SOS)$，

$$\frac{P(\pi_1^a, s_j)}{P(\pi_*)} \leqslant 1 + \frac{\beta_{max}L_{max}\sum_i Q_i}{P_1(\pi_1)}. \quad (24)$$

(1) 　　 ， 　　 ， 0， $P_1(\pi_1) > \sum_i \sum_j \sum_l Y_{[i]jl} c_j Q_{[i]}$， $c_{min} = \min_{j \in M}\{c_j\}$，

$$P_1(\pi_1) > c_{min}\sum_i Q_i. \quad (25)$$

(24) (25)

$$\frac{P(\pi_1^a, s_j)}{P(\pi_*)} \leqslant 1 + \frac{\beta_{max}L_{max}\sum_i Q_i}{c_{min}\sum_i Q_i} = 1 + \frac{\beta_{max}L_{max}}{c_{min}}.$$

， 　　 ， $\beta_{max} \leqslant c_{min}$， $\dfrac{P(\pi_1^a, s_j)}{P(\pi_*)} \leqslant 1 + L_{max}$， $P(\pi_1^a, s_j) \leqslant (L_{max}+1)P(\pi_*)$， H-3 $L_{max}+1$ 　　　 。 。

4.3

4.2 　　　　 ，H-3 　　 $L_{max}+1$ ， $L_{max}+1$ 　　　　　　 。

H-3 　　 ， $(n, m) = (10, 2)$ 　　　 10 　 100

，　　Hall

，　　　　　[2]　　　　　　，

，　　　　　　　　　　　　(Q_i, d_i)

。H-3　　　　　　　　　Lingo

，　　　C++　　　　　　。

　　　2　，H-3　　　　　　P_1

$P_1(\pi_1)$　　　P　　　　$P(\pi_*)$　　，

H-3　　　　P　　　$P(\pi_1^a, s_j)$

$P(\pi_*)$　　，　$P_1(\pi_1)$　LB，$P(\pi_1^a, s_j)$　UB，

$$ErrorRate = \frac{UB - LB}{LB},$$　　　1　1

，　　　　　　　　　10

。

，　　H-3

（2）　　$P_1(\pi_1)$　　　　$P(\pi_1^a, s_j)$

，　　H-3　　　　　　$P_1(\pi_1)$

，

$P(\pi_1^a, s_j)$　　。　　　4. 2　　1　　H-3

　　　　　　　　$L_{\max} + 1$，　　　　10

100　　　　$L_{\max} + 1$　8，

700％　　　　　，

3. 9％，　　　　　　　　，　　H-3

。

表1　H-3

	LB	UB	ErrorRate
1	5 828. 737	5 985	0. 026 8
2	7 086. 414	7 455	0. 052 0
3	5 636. 465	5 775	0. 024 5
4	7 820. 300	8 045	0. 028 7
5	6 414. 340	6 630	0. 033 6
6	6 835. 560	7 200	0. 053 3
7	3 933. 540	4 160	0. 057 5
8	5 541. 970	5 700	0. 028 5
9	5 804. 090	6 125	0. 055 2
10	5 246. 060	5 440	0. 036 9
Average	6 014. 748	6 251. 5	0. 039 3

图1　H-3性能分析

　　　1　1　　：

　　（1）10　　100　　　　　　　　　　　，

$ErrorRate$　　　5. 7％，　　　　　2. 4％，

3. 9％。　　　$P_1(\pi_1)$　$P(\pi_*)$　　　，　H-3

　　$P(\pi_1^a, s_j)$　　$P(\pi_*)$

5

，

，

，　　　　　　　　　　NP-

Hard　，

H-3，

，

$L_{\max} + 1$　　　　　，　　　　　　H-3

　　，　　H-3

。

，

。　　，

NP-Hard　，

，

[17]，

，

。

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大规模灾害中基于 FCMwNC 的医疗物资联合运送优化

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摘　要 针对应急医疗物资供应节点与需求节点距离太远或者通往灾区的关键道路遭到破坏等灾害情境, 对应急响应中的 "直升飞机 + 车辆" 医疗物资联合运送问题进行研究. 首先针对常规模糊 C- 均值 (FCM) 的在选择应急中转点和划分医疗救助点中的不足, 提出考虑医疗救助点数量约束的应急中转点选择方法 (FCMwNC), 接着考虑直升飞机飞行时间、应急中转点处的中转时间和车辆运送时间, 构建一个考虑中转时间的应急医疗物资联合运送优化模型. 数据实验验证了提出方法的有效性, 并得出一些结论: 1) FCMwNC 划分方法能够克服常规 FCM 划分中的医疗救助点个数不均衡问题, 进而能够有效缩短医疗救助点中的最大等待时间; 2) 随着应急中转点个数的增加, 总的联合运送时间、平均等待时间和最大等待时间都有降低的趋势; 3) 随着中转效率的增加, 总的联合运送时间、平均等待时间和最大等待时间会逐渐降低.

关键词 大规模灾害; 医疗物资; 联合运送; 中转点选择; 路线优化

A FCMwNC-based approach for medical supplies intermodal transportation in large-scale disasters

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Abstract Due to the long distances between supply nodes and demand nodes or the cut off of the key roads to affected areas, it is difficult or impossible to quickly transport medical supplies to affected areas only by vehicles, so we focus on the intermodal transportation of medical supplies by helicopters and vehicles. To overcome the shortages of the common fuzzy c-means (FCM) for selecting emergency distribution points (EDCs) and partitioning medical aid points (MAPs), we consider the constraints of the number of MAPs in each partition to develop an improved FCM approach with number constraints (FCMwNC) for selecting EDCs and partitioning MAPs; then, we consider the helicopter flight time, the transit time at EDCs and the vehicle travel time to build an intermodal transportation optimization model of medical supplies, which could produce the intermodal transportation routes. According to numerical experiments, we observed the following findings: 1) The developed FCMwNC method could overcome the imbalance of the number of MAPs in the FCM partitioning, which thus effectively shortens the biggest waiting time among MAPs; 2) As the increase of the number of selected EDCs, the total intermodal transportation time, average waiting time and biggest waiting time have decreasing trends; 3) As the increase of the transit efficiency, the total intermodal transportation time, average waiting time and biggest waiting time would be shortened with smaller ranges.

Keywords large-scale disasters; medical supplies; intermodal transportation; emergency distribution points selection; route optimization

0 引言

近些年发生了各种大规模灾害, 如 2005 年卡特里娜飓风、2008 年汶川地震、2009 年 H1N1 和 2013 年菲律宾台风等. 在对这些灾害响应的过程中, 及时的医疗服务和医疗物资对减少灾区的生命损失有着非常重要的影响 [1-2]. 然而, 应急物资运送往往面临很多挑战与困难, 这些挑战与困难在不同灾情下表现形式不同 [3-7]. 本文主要针对以下灾害情境: 由于应急医疗物资供应节点与需求节点距离太远或者通往灾区的关键道路遭到破坏, 导致难以在较短的时间内采用车辆把医疗物资运送到灾区的医疗救助点, 应急决策者不得不首先使用直升飞机把医疗物资运送到灾区的应急中转点, 之后采用车辆把医疗物资运送到医疗救助点.

我们从我国近些年的应急响应中提炼出以上研究问题. 在 2008 年的汶川地震中, 次生的滑坡和泥石流灾害阻断了通往灾区的关键道路, 使得外部救援车辆难以及时进入 "孤立" 的灾区, 一些关键物资和救援人员不得不通过直升飞机进行运送; 在 2010 年玉树地震中, 因为震区距省会的距离有 800 多公里, 距最近的火车站大概有 500 公里, 几乎所有的初始物资是通过直升飞机运送的; 由于意识到直升飞机在应急响应中的重要作用, 2013 年的雅安地震和汕头大水中, 应急决策者第一时间使用了直升飞机运送关键物资. 当前我国亟待需要建设社会化航空救援体系 [8], 但难免面临着许多难题. 其中一个关键难题是: 如何有效使用直升飞机运送医疗物资到灾区的医疗救助点. 由于直升飞机数量有限和起降条件的限制, 在大规模灾害中往往很难直接使用直升飞机运送医疗物资到每个医疗救助点, 需要考虑建立应急中转点, 首先使用直升飞机运送医疗物资到这些应急中转点, 之后使用车辆运送到每个医疗救助点.
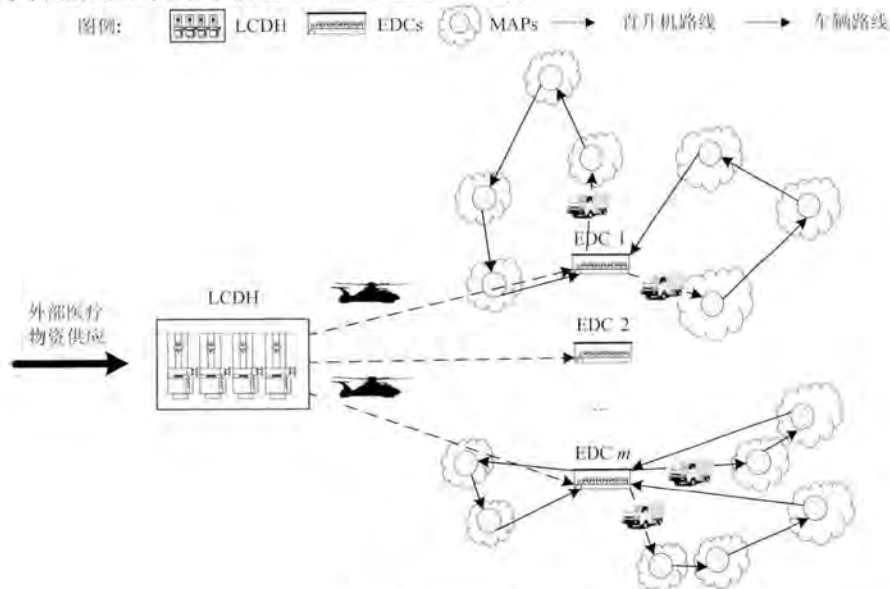
图 1 本文研究问题的示意图

因此, 本文研究的问题可以抽象为如图 1 所示: 在某大规模灾害中, 外部医疗物资汇集到大型集散中心 (LCDH), 首先采用直升飞机把医疗物资从大型集散中心运送到灾区的应急中转点 (EDCs), 之后采用车辆把医疗物资从应急中转点运送到医疗救助点 (MAPs). 这里主要有两个决策问题需要解决: 第一个是如何选择应急中转点的位置, 并确定每个应急中转点覆盖的医疗救助点, 这涉及到联合运送网络的确定; 第二个是如何安排应急医疗物资联合运送路线, 包括从大型集散中心到应急中转点的直升飞机路线和从应急中转点到其覆盖医疗救助点的车辆运送路线. 针对第一个问题, 本文首先针对常规模糊 C-均值 (FCM) 的在选择应急中转点和划分医疗救助点中的不足, 考虑每个聚类中的医疗救助点数量约束, 提出考虑数量约束的应急中转点选择方法 (FCMwNC); 针对第二个问题, 我们考虑直升飞机飞行时间、应急中转点处的中转时间和车辆运送时间, 构建一个应急医疗物资联合运送优化模型, 以确定具体的联合运送路线.

需要说明的是, 上述研究问题中设定联合运送模式是直升飞机与车辆联合运送, 这是根据我国应急响应实践提炼出来的一种典型联运模式. 但本文构建的应急中转点选择方法和联合运送优化模型不仅能够适用直升飞机与车辆联合运送, 也可以用于一些其它联合运送模式, 如直升飞机与人工转运联合 (只是在计算时的联合运送速度不同). 同时也可以通过增加路网约束, 进一步处理更广泛的联合运送模式, 如火车与车辆联合运送, 大型货车与小型车辆联合运送等.

1　相关研究

目前已有很多国内外学者对应急资源分配与运输优化等进行了研究, 详细进展可以参看一些文献综述 (如 [9] 和 [10]). 考虑到问题的相关性和篇幅限制, 这里仅对应急医疗物资优化方面的研究进行回顾与分析. 在应急医疗物资分配方面, Mete 等 [2] 首先采用情景分析方法分析可能发生的不同灾害类型和灾害级别, 在此基础上提出一个医疗物资存储与分配集成决策的随机优化方法; Arora 等 [11] 以大规模公共卫生安全事件为例, 提出一个医疗资源分配方法, 以优化公共卫生突发事件中的医疗救助; Ruan 等 [12] 提出一个基于情境的应急医疗物资分配方法, 能够为医疗救助点分配与其情境相符的应急物资比例; Yarmand 等 [13] 首先构建一个传染病动力学仿真模型, 进而把疫苗分配问题抽象成一个两阶段随机线性规划问题, 最终提出一个两阶段疫苗分配优化方法. 在应急医疗物资运输方面, 朱建明等 [14] 构建了一个应急医疗物资车辆优化调度模型, 以最小化未满足物资需求量和总的物资运输延误时间为目标, 并设计了模型求解的一个随机算法; 秦晓燕等 [15] 针对应急医疗血液这一特殊物资特点, 以最小化响应时间和调度总成本为目标, 建立了一个多时段、多类型血制品、多种运输方式的优化调度模型; 王恪铭等 [16] 以应急血液最晚运达时间最小、接收时的最低新鲜度最大、运输总费用最小为目标, 建立了一个应急血液调剂出救点选择与运输路线安排集成优化模型, 并设计了一种包含局部邻域优化的遗传求解算法. 可见, 越来越多学者关注应急医疗物资优化问题的研究, 为现实应急响应决策提供了一定的技术与方法, 但缺少对应急医疗物资多种模式联合运输优化问题的研究.

然而突发灾害的紧急性常常使得应急决策者采用不同的运送模式进行应急资源联合运送. 一些学者也对应急物资联合运送优化这一问题进行了探索与研究. Barbarosolu 等 [17] 把应急物资联合运输问题看成一个多物资多模式的网络流问题, 他们考虑资源调动和资源需求的随机性等, 构建了一个两阶段的多物资多模式随机规划模型; Özdamar[18] 同样把应急物流看成一个多周期多物资网络流问题, 构建了一个考虑不同运输模式效率的混合整数规划模型, 并通过拉格朗日松弛算法对构建的模型进行了求解; Hu[19] 针对应急物资运输集装箱的多式联运路径选择问题, 构建了一个多目标整数线性规划模型; Najafi 等 [20] 同时考虑地震中的应急物资运输和伤员运送, 构建了一个多目标多模式多周期的随机模型; 李双琳等 [21] 最短应急物资总配送时间和应急物资未满足的总损失最小为目标, 构建了一个震后应急物资配送的多目标选址 - 多式联运问题优化模型, 并设计了一种多目标遗传算法. 以上这些研究考虑不同方面构建了相应的应急物资联合运送优化模型, 为应急响应提供了各种的决策支持方法. 然而, 总的来看, 这些研究主要是考虑不同运输模式的运输效率与运输成本, 根据灾害响应中不同应急物资的需求紧迫程度, 为不同种类的应急物资选择不同类型的运输模式, 即不同运输模式同时都可用条件下的运输模式选择问题. 与这些研究不同的是, 本文的研究问题是由于距离太远或者关键道路阻断, 不得不采用 "直升飞机 + 车辆" 联合运送模式 (如图 1 所示); 相应地, 本文考虑的物资运送时间就与以上这些研究不同, 即不是假设不同运输模式具有不同的运输效率, 而是需要考虑包括直升飞机飞行时间、医疗物资中转时间和车辆运送时间的总联合运送时间.

2　模型构建

2.1　基于 FCMwNC 的应急中转点选择

如前所述, 本文研究问题中第一个需要解决的决策问题是如何选择出应急中转点的位置, 并确定每个中转点覆盖哪些医疗救助点, 这直接影响到应急医疗物资联合运送网络的结构, 也是进行联合运送路线优化的前提. 模糊 C- 均值 (FCM) 是一种最常用的聚类方法, 已被应用到各领域 [22−23]. 在 Ruan 等 [24] 中, 我们采用常规 FCM 进行应急中转点选择, 并根据每个医疗救助点的最大隶属度确定每个应急中转点覆盖的医疗救助点. 考虑表述的连续性, 这里简单介绍一下基于 FCM 的应急中转点选择方法. 拟采用的符号表示如下: n 表示某大规模灾害中医疗救助点的数量; A_j 表示第 j 个医疗救助点, $j = 1, 2, \cdots, n$; m 表示需要选择的应急中转点数量; C_i 表示第 i 个应急中转点, $i = 1, 2, \cdots, m$. 假定 u_{ij} 表示医疗救助点 A_j 属于应急中转点 C_i 的隶属度, $0 \leq u_{ij} \leq 1$, 其满足:

$$\sum_{i=1}^{m} u_{ij} = 1, \forall j = 1, 2, \cdots, n \tag{1}$$

FCM 算法聚类准则的目标函数为:

$$\min \left\{ \sum_{j=1}^{n} \sum_{i=1}^{m} (u_{ij})^{\omega} (d_{ij})^2 \right\} \tag{2}$$

其中 $(d_{ij})^2$ 表示应急中转点 C_i 和救助点 A_j 之间的距离 (本文采用欧氏距离, 即 $(d_{ij})^2 = \|A_j - C_i\|^2$), $\omega \in (1, \infty)$ 表示模糊加权系数. 根据拉格朗日乘数法, 可以把目标函数 (2) 转换成:

$$F = \sum_{j=1}^{n} \sum_{i=1}^{m} (u_{ij})^{\omega} (d_{ij})^2 + \sum_{j=1}^{n} \lambda_j \left(\sum_{i=1}^{m} u_{ij} - 1 \right) \tag{3}$$

其中 λ_j 表示约束条件 (1) 的拉格朗日乘子. 对目标函数 (3) 求导, 就可得到每个医疗救助点属于每个应急中转点的隶属度及选择的应急中转点位置:

$$u_{ij} = \frac{1}{\sum_{k=1}^{m} (\frac{d_{ij}}{d_{kj}})^{2/(\omega-1)}} \tag{4}$$

$$C_i = \frac{\sum_{j=1}^{n} (u_{ij})^{\omega} A_j}{\sum_{j=1}^{n} (u_{ij})^{\omega}} \tag{5}$$

最后, 根据每个医疗救助点的最大隶属度就可以确定每个应急中转点覆盖哪些医疗救助点.

虽然文献 [24] 提出的基于 FCM 的应急中转点划分方法能够使得选择出的应急中转点与其覆盖的医疗救助点之间的距离最小, 但不能克服其划分中医疗救助点数量的不均衡性, 可能影响到医疗救助点的平均等待时间和最大等待时间. 图 2 给出一个简单例子, 共有 9 个 MAPs, 需要选择出 2 个 EDCs 并确定每个中转点服务的 MAPs, 根据 FCM 的最小化距离聚类准则, 基于 FCM 方法的选择与划分结果如图 2(a) 所示: EDC1 服务 6 个 MAPs, 而 EDC2 仅服务 3 个 MAPs. 可见, 基于常规 FCM 的划分会导致划分中的医疗救助点数量不均衡性, 进而影响医疗物资到达救助点的平均等待时间和最大等待时间.
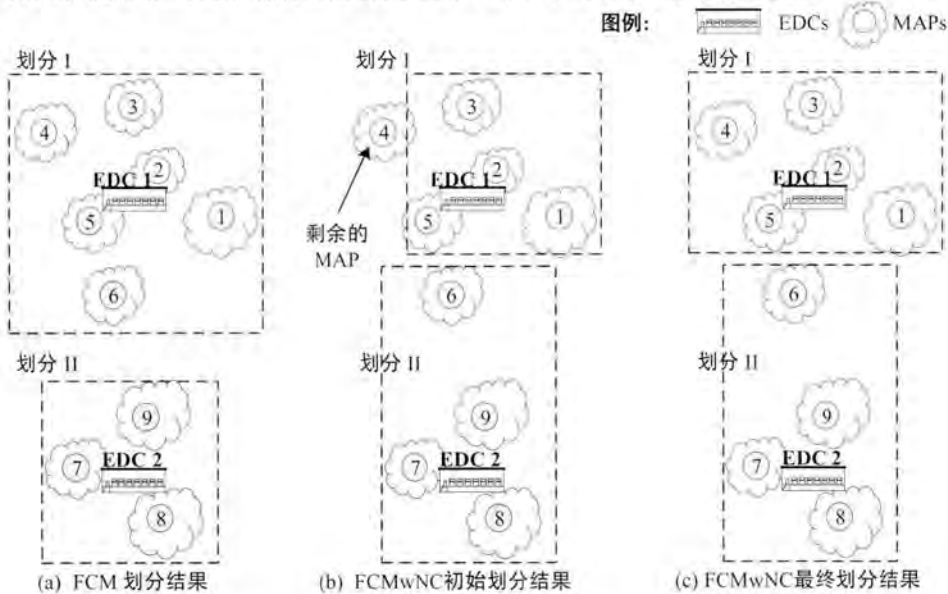
图 2 FCMwNC 划分示例

因此, 本文考虑每个划分中的医疗救助点数量约束, 提出一种 FCMwNC 方法, 使得每个划分中的医疗救助点数量尽量保持均衡, 以缩短联合运送的平均等待时间和最大等待时间. 对于 n 个医疗救助点, 如果要选择 m 个应急中转点, 依据每个划分中的医疗救助点数量均衡准则, 最均衡的划分是为每个划分分配 n/m 个医疗救助点. 如果 n/m 正好是一个整数, 则为第 i 个划分分配的医疗救助点个数为:

$$n^{C_i} = \frac{n}{m} \quad \forall i = 1, 2, \cdots, m \tag{6}$$

如果 n/m 不是一个整数, 则可以先分配距每个划分中心较近的 $[n/m]$ 个医疗救助点给相应的应急中转点, 其中函数 $[A]$ 返回比 A 小的最大整数; 之后再把剩余的 $n \bmod m$ 医疗救助点划分给据他们最近的应急中转点, 其中函数 $A \bmod B$ 返回 A 除以 B 的余数. 这里仍以图 2 中的例子来说明: 需要选择 2 个应急中转点服务 9 个应急中转点; 因为 9/2 的整数部分等于 4, 所以首先分别分配距每个划分中心较近的 4 个医疗救助点给每个 FCM 产生的划分, 即把 MAPs 1~3 和 MAP5 分给划分 I, 把 MAPs 6~9 分给划分 II(如图 2(b)), 然后把剩余的医疗救助点 (MAP4) 划分给距其最近的划分中心, 即把 MAP4 划给划分 I(如图 2(c)). 这就使得每个中转点服务的医疗救助点个数尽量均衡.

可见, FCMwNC 调整划分的准则是使得每个划分中的医疗救助点数量尽可能均衡, 即

$$\min \sum_{i=1}^{m} \left| n^{C_i} - \frac{n}{m} \right| \tag{7}$$

表示最小化最终划分中医疗救助点数量与最均衡划分中医疗救助点数量的总差.

为了把以上准则体现到常规 FCM 划分过程中, 我们引入一个惩罚因子 (一个较大的正数) 到 FCM 划分的目标函数中, 即 FCMwNC 的划分聚类目标函数为:

$$\min \left\{ \sum_{j=1}^{n} \sum_{i=1}^{m} (u_{ij})^{\omega} (d_{ij})^2 + M \sum_{i=1}^{m} \left| n^{C_i} - \frac{n}{m} \right| \right\} \tag{8}$$

如果考虑常规 FCM 方法中的约束 (1) 最小化目标函数 (8), 可以把基于 FCMwNC 的应急中转点选择方法看成以下有约束优化问题:

$$\min \left\{ \sum_{j=1}^{n} \sum_{i=1}^{m} (u_{ij})^{\omega} (d_{ij})^2 + M \sum_{i=1}^{m} \left| n^{C_i} - \frac{n}{m} \right| \right\}$$
$$\sum_{i=1}^{m} u_{ij} - 1 = 0, \forall j = 1, 2, \cdots, n \tag{9}$$
$$(d_{ij})^2 = \| A_j - C_i \|^2$$

根据拉格朗日乘数法, 可以把以上有约束优化问题转换为以下无约束优化问题:

$$F = \sum_{j=1}^{n} \sum_{i=1}^{m} (u_{ij})^{\omega} (d_{ij})^2 + M \sum_{i=1}^{m} \left| n^{C_i} - \frac{n}{m} \right| + \sum_{j=1}^{n} \lambda_j \left(\sum_{i=1}^{m} u_{ij} - 1 \right) \tag{10}$$

其中 λ_j 表示约束条件的拉格朗日乘子, 而 $(d_{ij})^2 = \| A_j - C_i \|^2$. 下节给出基于 FCMwNC 应急中转点选择及医疗救助点划分方法的一种启发式求解算法.

2.2 考虑中转时间的应急医疗物资联合运送优化模型

在确定了应急中转点的位置及每个中转点覆盖的医疗救助点之后, 应急医疗物资联合运送网络也就确定了, 接下来需要解决第二个决策问题, 即如何安排联合运送路线, 这里建立一个考虑中转时间的应急医疗物资联合运送优化模型. 首先补充一些新的符号定义: s 表示集散中心可用的医疗物资量; d_j 表示为救助点 A_j 分配的医疗物资量; Q_h 表示直升飞机最大容量; Q_v 表示车辆最大容量; N^{C_i} 表示应急中转点 C_i 覆盖的医疗救助点集合; $N_0^{C_i}$ 表示集合 N^{C_i} 与中转点 C_i 的并集; K^{C_i} 表示应急中转点 C_i 拥有的运输车辆集合; k^{C_i} 表示集合 K^{C_i} 中的元素个数; d_{LC_i} 表示从大型集散中心 LCDH 到应急中转点 C_i 的距离, $i = 1, 2, \cdots, m$; $d_{jl}^{C_i}$ 表示中转点 C_i 与其覆盖的 MAPs 之间任意两点的距离, $\forall i \in \{1, 2, \cdots, m\}$, $j, l \in N_0^{C_i}$; v_h 表示直升飞机飞行速度; v_v 表示车辆行驶速度; $q_{jlk}^{C_i}$ 表示车辆 k 从 A_j 驶向 A_l 时可用的应急医疗物资量. 决策变量包括: $x_{jlk}^{C_i}$ 为二进制变量, $x_{jlk}^{C_i} = 1$ 表示车辆 k 从 A_j 经过 A_l (否则 $x_{jlk}^{C_i} = 0$), $\forall i \in \{1, 2, \cdots, m\}$, $j, l \in N_0^{C_i}$, $k \in K^{C_i}$; $u_{jk}^{C_i}$ 为二进制变量, $u_{jk}^{C_i} = 1$ 表示 A_j 由车辆 k 服务 (否则 $u_{jk}^{C_i} = 0$), $\forall i \in \{1, 2, \cdots, m\}$, $j \in N_0^{C_i}$, $k \in K^{C_i}$.

应急医疗物资运送的效率直接影响到医疗物资使用的效用, 应急响应中应在最短时间内把所需的医疗物资运送到每个医疗救助点, 因此, 本文的优化目标设定为最小化总的联合运送时间 (TTT). 从大型集散中心到中转点再到医疗救助点所需的时间主要包括: 1) 在集散中心把医疗物资装载到直升飞机上的装载时间, 即为 t_L; 2) 从集散中心到中转点 C_i 的直升飞机飞行时间, 即为 t_{LC_i}; 3) 在中转点医疗物资从直升飞机转载到运输车辆上的中转时间, 即为 t_{C_i}; 4) 从中转点到救助点 A_j 的车辆行驶时间, 即为 $t_{C_i A_j}$; 5) 到达救助点 A_j 后从车辆上卸载医疗物资的时间, 即为 t_{A_j}, 如图 3 所示.
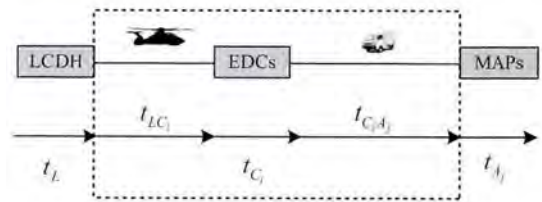
图 3　应急医疗物资联合运送时间示意图

不失一般性, 本文忽略在集散中心的装载时间和到达救助点后的卸载时间, 仅考虑 t_{LC_i}、t_{C_i} 和 $t_{C_i A_j}$. 其中, t_{LC_i} 主要与从集散中心到中转点 C_i 的距离和直升飞机飞行速度有关; t_{C_i} 与在中转点 C_i 中转的医疗物资数量和中转效率有关; $t_{C_i A_j}$ 与中转点 C_i 到救助点 A_j 的距离和车辆行驶速度有关 (这里仅在概念上用 $t_{C_i A_j}$ 表示从中转点 C_i 到救助点 A_j 经过的时间, 并不应用到构建的模型中). 基于以上分析, 本文构建的应

急医疗物资联合运送优化模型如下:

$$\min \sum_{i=1}^{m} \left(d_{LC_i}/v_h + \sum_{j \in N^{C_i}} d_j/\theta + \sum_{k \in K^{C_i}} \sum_{j \in N_0^{C_i}} \sum_{l \in N_0^{C_i}, l \neq j} (d_{jl}^{C_i}/v_v) x_{jlk}^{C_i} \right) \tag{11}$$

约束条件:

$$s = \sum_{j=1}^{n} d_j = \sum_{i=1}^{m} \sum_{k \in K^{C_i}} \sum_{j \in N_0^{C_i}} \sum_{l \in N_0^{C_i}, l \neq j} d_j x_{jlk}^{C_i} \tag{12}$$

$$\sum_{k \in K^{C_i}} \sum_{j \in N_0^{C_i}} \sum_{l \in N_0^{C_i}, l \neq j} d_j x_{jlk}^{C_i} \leq Q_h \ \forall i \in \{1, 2, \cdots, m\} \tag{13}$$

$$\sum_{k \in K^{C_i}} u_{jk}^{C_i} = 1 \ \forall i \in \{1, 2, \cdots, m\}, \forall j \in N_0^{C_i} \tag{14}$$

$$\sum_{k \in K^{C_i}} u_{0k} = \sum_{k \in K^{C_i}} u_{k0} \leq k^{C_i} \ \forall i \in \{1, 2, \cdots, m\} \tag{15}$$

$$\sum_{h \in N_0^{C_i}, j \neq h} x_{hjk}^{C_i} = \sum_{l \in N_0^{C_i}, j \neq l} x_{jlk}^{C_i} = u_{jk}^{C_i} \ \forall i \in \{1, 2, \cdots, m\}, \forall k \in K^{C_i} \tag{16}$$

$$\sum_{j \in N^{C_i}} d_j \times u_{jk}^{C_i} - \sum_{l \in N^{C_i}} q_{0lk}^{C_i} = 0 \ \forall i \in \{1, 2, \cdots, m\}, \forall k \in K^{C_i} \tag{17}$$

$$q_{jlk}^{C_i} \leq Q_v \times x_{jlk}^{C_i} \ \forall i \in \{1, 2, \cdots, m\}, \forall j, l \in N_0^{C_i}, \forall k \in K^{C_i} \tag{18}$$

$$x_{jlk}^{C_i} = \{0, 1\}, \quad u_{jk}^{C_i} = \{0, 1\}, \quad i \in \{1, 2, \cdots, m\}, \quad h, j, l \in N_0^{C_i}, k \in K^{C_i} \tag{19}$$

在目标函数 (11) 中, d_{LC_i}/v_h 表示从集散中心到应急中转点 C_i 的直升飞机飞行时间; $\sum_{j \in N^{C_i}} d_j/\theta$ 表示在中转点 C_i 处的医疗物资中转时间 (θ 表示医疗物资中转效率, 即每单位时间中转的医疗物资数量); $\sum_{k \in K^{C_i}} \sum_{j \in N_0^{C_i}} \sum_{l \in N_0^{C_i}, l \neq j} (d_{jl}^{C_i}/v_v) x_{jlk}^{C_i}$ 表示从中转点 C_i 到其覆盖救助点的车辆行驶时间. 约束条件 (12) 保证运送到所有医疗救助点的医疗物资总量等于集散中心当前可用的物资量; 约束条件 (13) 保证从集散中心运到每个中转点的医疗物资量不能超过直升飞机的最大容量 Q_h; 约束条件 (14) 保证每个医疗救助点仅被一辆车访问一次; 约束条件 (15) 保证每辆车从其应急中转点出发并最终返回到它所在的中转点; 约束条件 (16) 保证到达医疗救助点 A_j 的车辆必须从该医疗救助点离开; 约束条件 (17) 和 (18) 保证运输车辆不能装载多于最大承载量的医疗物资; 约束条件 (19) 定义各变量的范围.

该模型的目标考虑的是总医疗物资联合运送时间, 而在应急响应中往往还考虑其他时间指标, 如医疗救助点接收到医疗物资的平均等待时间 (AWT) 和最大等待时间 (BWT), 这里给出它们的测量公式:

1) 平均等待时间

$$AWT = \frac{\sum_{i=1}^{m} \left(\frac{d_{LC_i}}{v_h} + \frac{\sum_{j \in N^{C_i}} d_j}{\theta} + \sum_{j \in N^{C_i}} ariv_j^{C_i} \right)}{n} \tag{20}$$

其中, $ariv_j^{C_i}$ 表示从某车辆离开中转点 C_i 到该车辆到达医疗救助点 A_j 时已经流逝的时间, $j \in N^{C_i}$. 注意这里不包括车辆从最后一个救助点返回中转点 C_i 所经历的时间, 即公式中 $j \in N^{C_i}$ 而不是 $j \in N_0^{C_i}$. 很明显, 平均等待时间越小越好, 因为医疗救助点越早接收到医疗物资, 这些物资的效用就越大.

2) 最大等待时间

$$BWT = \max_{i=1}^{m} \left(\frac{d_{LC_i}}{v_h} + \frac{\sum_{j \in N^{C_i}} d_j}{\theta} + \max_{k \in K^{C_i}} \sum_{j \in N_0^{C_i}} \sum_{l \in N^{C_i}, l \neq j} \frac{d_{jl}^{C_i}}{v_v} x_{jlk}^{C_i} \right) \tag{21}$$

最大等待时间即为最晚接收到医疗物资的那个医疗救助点等待的时间, 实际中应急决策者往往需要考虑最大等待时间, 这涉及到应急物资运送的公平性. 同样, 这里也不包括车辆从最后一个救助点返回中转点 C_i 所经历的时间.

3　求解方法

3.1　基于 FCMwNC 的启发式求解算法

为了改善基于常规 FCM 的划分结果, 2.1 节考虑医疗救助点数量约束, 提出了基于 FCMwNC 的应急中转点选择和医疗救助点划分方法. 本节给出该方法的一个启发式求解算法.

FCMwNC 算法的输入 n: 医疗救助点的数目; $A_j, j = 1, 2, \cdots, n$: 医疗救助点的位置; m: 需要选择应急中转点的数目; ω: FCM 的模糊加权系数. ε: FCM 的迭代终止阈值.

FCMwNC 算法的输出 $C_i^{(t)}$: 选择的应急中转点位置; N^{C_i}: 调整后的医疗救助点划分, 即 N^{C_i}.

算法步骤如下:

步骤 1　初始化参数 $n, A_j, m, \omega, \varepsilon$;

步骤 2　随机生成一个初始隶属度矩阵 $U^{(0)} = [u_{ij}]_{m \times n}$, 其中 $0 \leq u_{ij} \leq 1, \sum_{i=1}^{m} u_{ij} = 1, \forall j = 1, 2, \cdots, n$;

步骤 3　利用 $C_i^{(t)} = \sum_{j=1}^{n} (u_{ij}^{(t)})^{\omega} A_j / \sum_{j=1}^{n} (u_{ij}^{(t)})^{\omega}$ 计算应急中转点的位置 $C_i^{(t)}$, $i = 1, 2, \cdots, m$, 其中 t 表示迭代步长;

步骤 4　利用公式 $J^{(t)} = \sum_{j=1}^{n} \sum_{i=1}^{m} (u_{ij}^{(t)})^{\omega} (d_{ij})^2$ 和 $(d_{ij})^2 = \|A_j - C_i^{(t)}\|^2$, 我们可以计算目标函数值; 如果 $\max_{ij}\{|u_{ij}^{(t)} - u_{ij}^{(t-1)}|\} < \varepsilon$, 则终止迭代, 记录 $C_i^{(t)}$, $U^{(t)}$ 和 $J^{(t)}$ 的值, 转到步骤 6;

步骤 5　利用 $u_{ij} = 1/\sum_{k=1}^{m} (\frac{d_{ij}}{d_{kj}})^{2/(\omega-1)}$ 计算新的隶属度矩阵 $U^{(t+1)}$, 令 $t = t + 1$, 转向步骤 2;

步骤 6　根据隶属度矩阵 $U^{(t)}$, 计算每个医疗救助点 A_j 属于应急中转点 $C_i^{(t)}$ 的最大隶属度, 确定每个应急中转点 $C_i^{(t)}$ 覆盖的医疗救助点集合及其中的元素个数, 即 N^{C_i} 和 n^{C_i}; 记录 $C_i^{(t)}$, $U^{(t)}$, $J^{(t)}$, N^{C_i} 和 n^{C_i} 的值, 同时设定一个状态变量集合 $flag = \{C_i, i = 1, 2, \cdots, m\}$, 转到步骤 7;

步骤 7　如果 n/m 正为整数, 则转向步骤 8; 如果不为整数, 选择出 $n \bmod m$ 个具有第二大隶属度的医疗救助点, 使得剩余的医疗救助点正好可以平均划分, 则转向步骤 10;

步骤 8　计算状态变量集合 $flag$ 中每个划分的 $n^{C_i} - n/m$ 值, 可确定 $n^{C_i} - n/m$ 值最大的划分, 即当前状态变量集合 $flag$ 中具有最多剩余医疗救助点个数的划分, 按照该划分中医疗救助点的第二大隶属度大小, 从该划分中选择出 $n^{C_i} - n/m$ 个医疗救助点; 从状态变量集合 $flag$ 中删除该划分, 转向步骤 9;

步骤 9　把步骤 8 中选择出来的若干个医疗救助点分别划分给状态变量集合 $flag$ 中其第二大隶属度的那个划分, 更新 N^{C_i}; 如果状态变量集合 $flag$ 中的元素个数等于 0, 记录调整后的 N^{C_i}, 转向步骤 12, 否则, 转向步骤 7;

步骤 10　计算状态变量集合 $flag$ 中每个划分的 $n^{C_i} - [n/m]$ 值, 可确定 $n^{C_i} - [n/m]$ 值最大的划分, 即当前状态变量集合 $flag$ 中具有最多剩余医疗救助点个数的划分, 按照该划分中医疗救助点的第二大隶属度大小, 从该划分中选择出 $n^{C_i} - [n/m]$ 个医疗救助点; 从状态变量集合 $flag$ 中删除该划分, 转向步骤 11;

步骤 11　把步骤 10 中选择出来的若干个医疗救助点分别划分给状态变量集合 $flag$ 中其第二大隶属度的那个划分, 更新 N^{C_i}; 如果状态变量集合 $flag$ 中的元素个数等于 0, 把步骤 7 事先选择出的 $n \bmod m$ 个分别划分给其隶属度最大的划分, 更新 N^{C_i}, 记录调整后的 N^{C_i}, 转向步骤 12, 否则, 转向步骤 10;

步骤 12　输出 $C_i^{(t)}$ 和调整后的 N^{C_i}.

3.2　联合运送优化模型的求解方法

我们采用 Matlab 实现了 3.1 中的基于 FCMwNC 的启发式求解算法, 能够确定需要选择的应急中转点的位置及每个中转点覆盖的医疗救助点. 而对于 2.2 节中构建的考虑中转时间的应急医疗物资联合运送优化模型, 可以看成是一个整数规划模型, 本文采用 IBM 公司的 ILOG CPLEX 9.0 对其进行求解. 第 4 节数值实验中拟给出具体算法和模型的相关参数取值.

从整体求解算法上来看, 本文首先采用 FCMwNC 算法确定应急中转点位置和医疗救助点划分, 进而在不同划分内进行运送路线优化, 即本文算法属于 "Divide and Conquer" 策略. 按照文献 [25–26] 的分析, 本文求解算法复杂度会随着中转点个数的增加而递减, 而且减少幅度递增, 一直到中转点个数与医疗救助点个数相等为止.

4　数值实验

为了验证本文提出方法的有效性, 本节采用随机生成的实验数据, 首先给出应急中转点个数和中转效率固定情况下的应急中转点选择结果和联合运送路线结果, 接着分别分析不同应急中转点个数和不同中转效率

对联合运送绩效的影响.

4.1 实验数据

假定一次传染性疾病中, 某区域内建立了 50 个医疗救助点 (MAPs), 如图 4 所示 (星号表示 MAPs, 其坐标从 0 到 200 随机生成; 方框表示大型集散中心 (LCDH), 其坐标为 (100, 100)); 现在需要将集散中心的一批疫苗尽快送到每个 MAP, 考虑到 MAPs 距 LCDH 距离太远, 决策者决定使用直升飞机和车辆联合运送; 从 200 到 500 随机产生为每个 MAP 分配的疫苗量, 如表 1 所示.
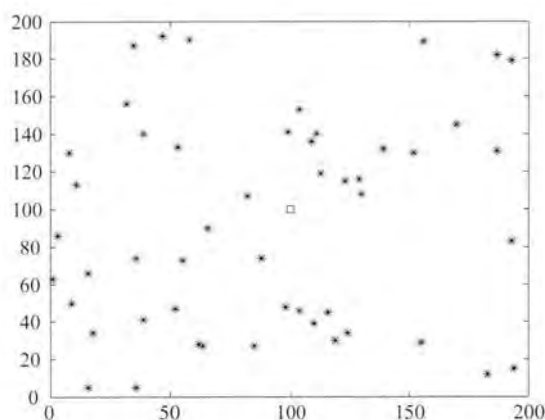
4.2 EDCs 个数为 5 和疫苗中转效率为 1000 时的结果与分析

考虑到不同应急中转点个数和不同疫苗中转效率会对联合运送绩效有影响, 本节设定应急中转点个数为 5,

图 4 医疗救助点和集散中心位置

表 1 医疗救助点坐标及分配的疫苗量

MAPs	x	y	d_j	MAPs	x	y	d_j	MAPs	x	y	d_j
1	119	30	428	18	88	74	390	35	47	192	293
2	16	5	401	19	130	108	494	36	194	15	416
3	35	187	228	20	111	140	295	37	110	39	441
4	129	116	425	21	193	83	237	38	170	145	216
5	3	86	304	22	155	29	465	39	113	119	479
6	187	182	255	23	8	130	350	40	183	12	294
7	104	46	438	24	53	133	249	41	66	90	422
8	109	136	228	25	104	153	272	42	124	34	441
9	139	132	434	26	36	5	252	43	193	179	372
10	64	27	420	27	116	45	402	44	36	74	248
11	82	107	403	28	16	66	364	45	156	189	230
12	85	27	264	29	58	190	263	46	9	50	388
13	55	73	347	30	99	141	445	47	11	113	434
14	32	156	384	31	18	34	266	48	98	48	500
15	62	28	429	32	152	130	372	49	123	115	373
16	39	140	309	33	39	41	394	50	1	63	262
17	52	47	490	34	187	131	435				

疫苗中转效率为 1000. 采用常规 FCM 算法和 3.1 提出的基于 FCMwNC 的启发式算法 (模糊加权系数 $\omega = 2$; 迭代终止阈值 $\varepsilon = 1 \times 10^{-5}$; 最大迭代次数为 300, 可以得到这两种方法选择应急中转点和划分医疗救助点的结果, 分别如表 2 和表 3 所示.

表 2 基于常规 FCM 的应急中转点选择与医疗救助点划分结果

EDCs	x	y	N^{C_i}	n^{C_i}
EDC1	117.9331	37.9127	{1, 7, 12, 18, 22, 27, 36, 37, 40, 42, 48}	11
EDC2	117.3180	123.9910	{4, 8, 9, 11, 19, 20, 25, 30, 32, 39, 49}	11
EDC3	30.6857	47.7180	{2, 5, 10, 13, 15, 17, 26, 28, 31, 33, 41, 44, 46, 50}	14
EDC4	38.3527	153.4735	{3, 14, 16, 23, 24, 29, 35, 47}	8
EDC5	176.9927	158.0736	{6, 21, 34, 38, 43, 45}	6

表 3 基于 FCMwNC 的应急中转点选择与医疗救助点划分结果

EDCs	x	y	N^{C_i}	n^{C_i}
EDC1	117.9331	37.9127	{1, 10, 12, 15, 22, 27, 36, 37, 40, 42}	10
EDC2	117.3180	123.9910	{7, 8, 18, 20, 25, 30, 39, 41, 48, 49}	10
EDC3	30.6857	47.7180	{2, 13, 17, 26, 28, 31, 33, 44, 46, 50}	10
EDC4	38.3527	153.4735	{3, 5, 11, 14, 16, 23, 24, 29, 35, 47}	10
EDC5	176.9927	158.0736	{4, 6, 9, 19, 21, 32, 34, 38, 43, 45}	10

从表 2 和表 3 的最后两列, 我们可以看出: 采用常规 FCM 划分会导致每个划分覆盖的医疗救助点个数不均衡, 分别为 11、11、14、8 和 6; 而采用 FCMwNC 方法可以产生医疗救助点个数均衡的划分, 每个划分

都包括 10 个医疗救助点.

　　基于表 2 和表 3 的划分结果, 结合表 1 中各医疗救助点的坐标和需求量数据, 采用 CPLEX 9.0 对 2.2 节建立医疗物资联合运送路线优化模型进行求解 (CPLEX 最大计算时间设置为 3600 秒, 其他参数为默认值), 可以得到具体的联合运送路线, 如图 5 所示 (其中虚线为直升飞机运送路线, 实线为车辆运送路线). 其中模型相关参数为: 车辆最大容量 $Q_v = 2000$; 直升飞机最大容量 $Q_h = 20000$; 直升飞机飞行速度 $v_h = 5$; 车辆行驶速度 $v_v = 1$; 疫苗中转效率 $\theta = 1000$ (这里车辆容量、直升飞机容量和疫苗中转效率, 是根据疫苗体积较小进行相应设置的, 因此得出的结果仅适用于体积较小的医疗物资, 而对于体积较大的医疗物资 (如医疗设备) 不适用).

　　具体联合运送结果为: 基于 FCM 划分的联合运送总时间为 1527.01, 医疗救助点平均等待时间为 89.83, 最大等待时间为 274.61, 使用 5 架直升飞机和 12 辆车辆; 基于 FCMwNC 划分的联合运送总时间为 1691.25, 医疗救助点平均等待时间为 91.89, 最大等待时间为 249.19, 同样使用 5 架直升飞机和 12 辆车辆. 通过对比可以看出: FCMwNC 均衡的划分在基本保持医疗救助点平均等待时间的条件下有效缩短了最大等待时间 (从 274.61 缩短到 249.19), 虽然需要更长的联合运送总时间. 然而, 这两种方法都存在一定的不足, 由于划分导致某些车辆只配送相对较少的医疗救助点, 如图 5 中的加粗路线表示.

(a) 基于 FCM 划分　　　　　　　　　　　　　(b) 基于 FCMwNC 划分
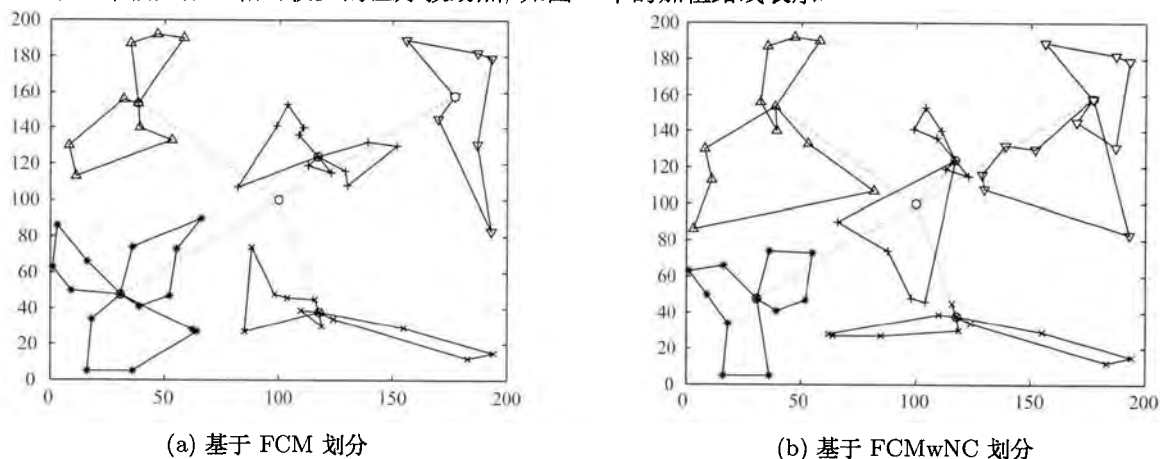
图 5　应急医疗物资联合运送路线优化结果

4.3　不同 EDCs 个数下的联合运送结果

　　为了进一步分析不同应急中转点下的联合运送绩效, 本节保持其他参数不变, 改变应急中转点的个数, 从 2 到 8. 两种划分方法下的联合运送结果如表 4 所示. 可以看出: 1) 随着应急中转点个数的增加, 总的联合运送时间有缩短的趋势, 虽然存在一定波动, 总体上仍是 FCM 方法产生的 TTT 小于 FCMwNC 方法产生的 TTT; 2) 随着中转点个数的增加, 两种方法产生的平均等待时间也有降低趋势 (也存在波动), 但是并不能确定哪种方法产生的 AWT 存在绝对优势, 如图 6(a) 所示; 3) 从最大等待时间来看, 随着中转点个数的变化, FCMwNC 方法往往优于 FCM 方法, 如图 6(b) 所示.

表 4　不同 EDCs 个数下的联合运送结果

	EDCs 个数	TTT	AWT	BWT	使用的车辆个数
	2	1859.59	105.08	337.66	11
	3	1714.92	96.92	308.95	11
	4	1584.30	95.18	293.41	12
FCM	5	1527.01	89.83	274.61	12
	6	1550.08	72.15	275.52	13
	7	1531.25	90.54	275.37	13
	8	1460.77	70.63	207.04	12
	2	1851.72	105.81	337.97	11
	3	1832.57	106.31	296.43	11
	4	1759.38	94.72	265.95	12
FCMwNC	5	1691.25	91.89	249.19	12
	6	1628.43	70.13	211.42	13
	7	1630.21	68.72	189.64	14
	8	1598.67	65.93	145.30	13

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(a) 平均等待时间   (b) 最大等待时间
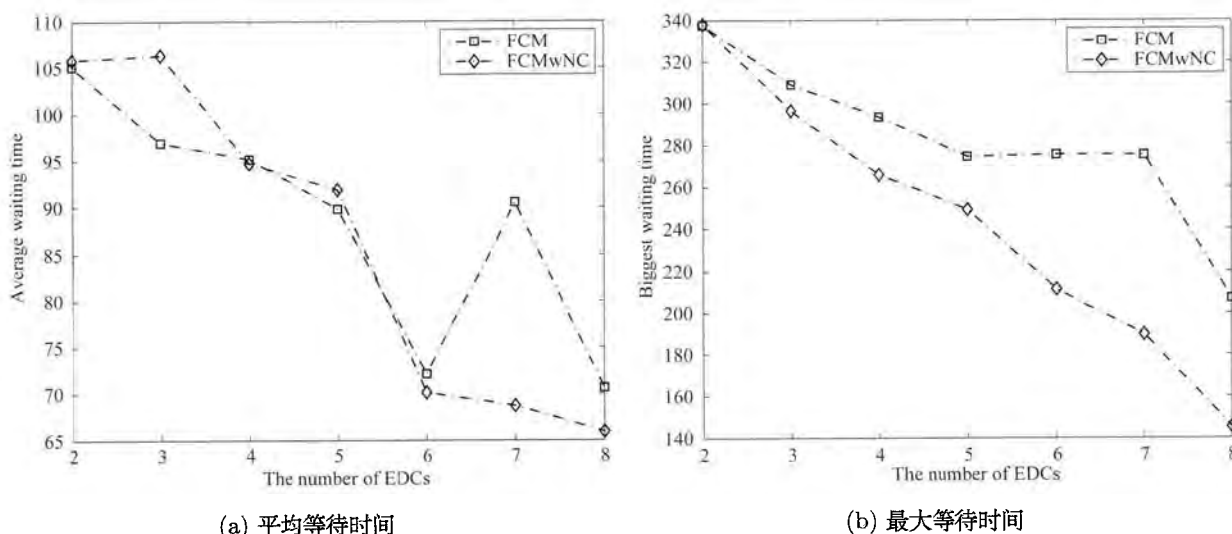
图 6　不同 EDCs 个数下的平均等待时间和最大等待时间

4.4　不同中转效率下的联合运送结果

在 4.2 和 4.3 节中, 我们考虑到疫苗体积较小, 假定疫苗中转效率为 1000, 然而实际应急响应中医疗物资中转效率可能会因医疗物资体积、中转点人力和交通情况等因素发生变化, 进而影响到联合运送绩效. 本节保持其他模型参数不变, 改变医疗物资中转效率, 首先以 40 为差额从 40 到 200, 接着以 200 为差额从 200 到 1600, 具体结果如表 5 所示. 可以看出: 1) 随着中转效率的增加, 两种划分方法下的总联合运送时间都逐渐降低, 但降低幅度逐渐变小; 2) 随着中转效率的增加, 两种划分方法下的平均等待时间和最大等待时间也都逐渐降低; 3) 随着中转效率超过 80, FCMwNC 方法在最大等待时间上明显优于常规 FCM 方法 (如图 7(b) 所示), 而二者在平均等待时间上的差别较小 (如图 7(a) 所示).

另外需要说明的是, 本节所有实验的 CPU 运行时间都相对很短, Matlab 中划分运行时间与 CPLEX 路线优化时间的和都不超过 60 秒, 因此, 适合处理应急响应情境.

表 5　不同中转效率下的联合运送结果 (中转点个数为 5)

	疫苗中转效率	TTT	AWT	BWT	使用的车辆个数
	40	1957.59	183.93	316.48	12
	80	1733.33	134.92	294.67	12
	120	1658.57	118.58	287.40	12
	160	1621.20	110.41	283.76	12
	200	1598.77	105.51	281.58	12
FCM	400	1553.92	95.71	277.22	12
	600	1538.97	92.44	275.77	12
	800	1531.49	90.81	275.04	12
	1000	1527.01	89.83	274.61	12
	1200	1524.02	89.17	274.31	12
	1400	1521.88	88.71	274.10	12
	1600	1520.28	88.36	273.95	12
	40	2121.83	178.01	328.25	12
	80	1897.57	133.15	286.18	12
	120	1822.81	118.20	272.78	12
	160	1785.44	110.73	266.08	12
	200	1763.01	106.24	262.06	12
FCMwNC	400	1718.16	97.27	254.01	12
	600	1703.21	94.28	251.33	12
	800	1695.73	92.79	249.99	12
	1000	1691.25	91.89	249.19	12
	1200	1688.26	91.29	248.65	12
	1400	1686.12	90.86	248.27	12
	1600	1684.52	90.54	247.98	12

(a) 平均等待时间　　　　　　　　　　　　　　　(b) 最大等待时间
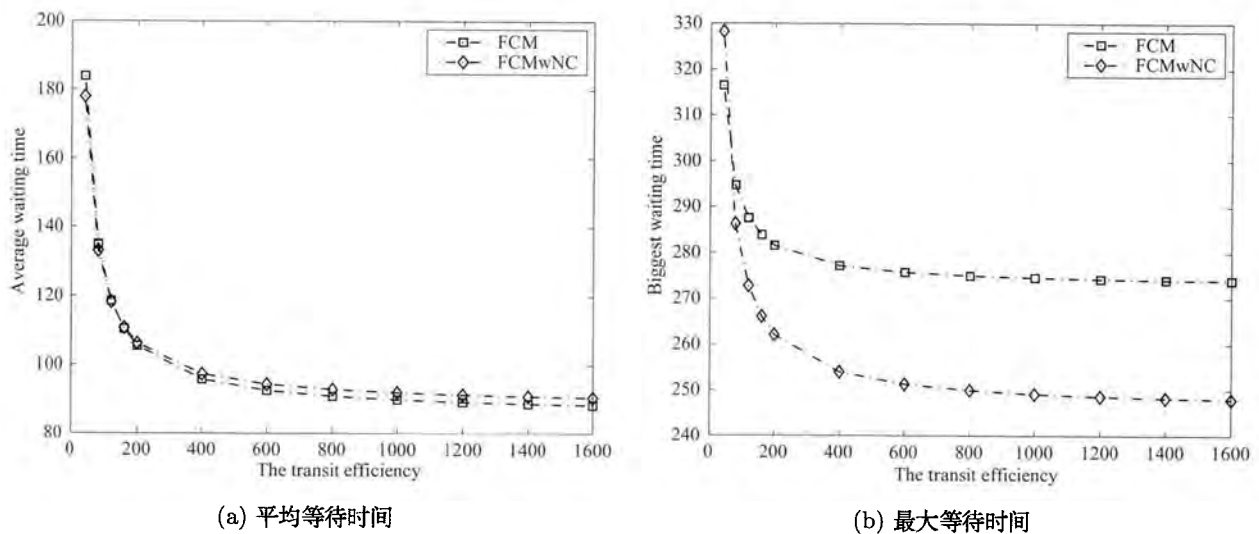
图 7 不同中转效率下的平均等待时间和最大等待时间

5　结束语

针对应急医疗物资供应节点与需求节点距离太远或者通往灾区的关键道路遭到破坏等灾害情境, 本文对应急响应中的 "直升飞机 + 车辆" 医疗物资联合运送问题进行了研究, 首先针对常规 FCM 聚类在医疗救助点划分中存在的不足, 提出一个考虑医疗救助点数量约束的 FCMwNC 划分方法, 并设计了相应启发式算法, 接着建立了一个考虑中转时间的联合运送优化模型, 最后采用随机数据进行了数据实验. 根据实验结果, 可以得出以下结论:

1) FCMwNC 划分方法能够克服常规 FCM 划分中的医疗救助点个数不均衡问题, 进而能够在基本保持平均等待时间不发生较大延迟的条件下有效缩短医疗救助点中的最大等待时间, 在更大程度上考虑了应急响应中物资运送的公平性.

2) 随着应急中转点的增加, 总的联合运送时间、平均等待时间和最大等待时间都有降低的趋势, 但降低的幅度会逐渐下降, 这就说明了在应急响应中, 需要根据当前医疗救助点的个数和位置选择最优的应急中转点个数.

3) 随着中转效率的增加, 总的联合运送时间、平均等待时间和最大等待时间会逐渐降低, 因此, 在应急医疗物资联合运送中, 需要考虑中转点的物资中转效率问题, 例如需要配置相匹配的中转人力, 以最大发挥联合运送优势.

然而, 由于研究问题的复杂性, 本文方法和结论难免存在一定的局限性, 例如本文结论难以适用于体积较大的应急医疗物资 (如医疗设备); 同时本文提出的方法存在一些需要进一步改进之处, 例如如何避免划分中某些车辆配送较少医疗救助点这一问题. 在未来研究中, 我们主要从以下两个方面进行扩展: 考虑现实路网约束, 把本文方法和模型扩展到铁路与公路等联合运送模式; 考虑需求和运送的不确定性, 把本文方法和模型扩展成随机模型, 为具有不同情境下的应急物资运送提供方法支持.

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	5. 058	0. 981
	4. 892	1. 011
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		T	P		Cronbach´a	SMC*	C. R.	AVE
CI₁	0.96	4.465	***	0.572		0.327		
CI₂	0.91	4.821	***	0.665		0.442		
CI₃	1			0.622	0.718	0.387	0.724	0.597
CI₄	0.99	4.801	***	0.657		0.432		
CA₁	0.993	14.72	***	0.905		0.819		
CA₂	1			0.936		0.876		
CA₃	0.842	11.611	***	0.792	0.846	0.627	0.867	0.633
CA₄	0.644	5.275	***	0.458		0.21		
OI₁	1			0.92		0.846		
OI₂	0.926	12.688	***	0.877	0.901	0.769	0.902	0.755
OI₃	0.799	11.259	***	0.806		0.65		
OE₁	0.99	14.559	***	0.891		0.794		
OE₂	1			0.966	0.905	0.933	0.91	0.772
OE₃	0.863	11.107	***	0.768		0.59		

: ***   0.1%   ; SMC   Squared Multiple Correlation

（CR）

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χ^2/DF	1.748
GFI	0.876≈0.90
AGFI	0.819
PGFI	0.601
NFI	0.890
IFI	0.950
CFI	0.949
PNFI	0.704
NCP	53.832
RMSEA	0.059

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	Estimate	T	P	
—>	0.432	4.949	***	3
—>	0.521	5.784	***	2
—>	0.476	3.471	***	4
—>	0.309	2.629	0.009	1
—>	0.331	3.174	0.033	6
—>	0.186	3.366	***	5

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: *** 　　　　　　0.1% 　　　　Estimate

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—>	0.56	0.31	0.25
—>	0.48	0.48	—
—>	0.35	0.19	0.16

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Inputs of Production Factors for Different Operational Types of Commercial Forests and the Technical Efficiency in the Reform of Collective Forestry Property Right System:
Based on Three Stage DEA Model and Household Data of Fujian and Jiangxi Province

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Abstract: The status quo about household's production factors inputs and the efficiency were analyzed with a three-stage DEA Model based on the data collected from households in Fujian and Jiangxi Province covering the period of 2007 – 2011. It was found that household's forestland management was still at the stage of extensive operation. The operation still preferred a shorter cycle of economic forest. The inputs of labor and funds on economic forest were higher than on wood   wood with bamboo management type. But the comprehensive technical efficiency of the economic forest management was lower than wood   wood with bamboo management mode. The scale efficiency was low   which led to low technical efficiency. After getting rid of environment variables and random factors   the pure technical efficiency rose by 35.96%   scale efficiency lowed by 34.83%   thus the average technical efficiency decreased by 11.36%. Further improvement of the forest right reform and supporting service measures   such as reducing the difficulty of application for harvesting index   and forest right certification   and relieving taxes   was able to significantly improve the efficiency of the production of commercial forest. The older age and higher education level of the householders   and the more rainfall improved the technical efficiency; on the contrary   the higher ratio of off-farm income to total income   the more number of

forest land parcel and the farther distances of forestland from roads reduced the technical efficiency. These results suggest that the suitable measure and relevant service should be improved by related government departments in order to raise the commercial forest technical efficiency and to increase farmer's income in rich forest regions.

Key words: forest tenure reform; Fujian; Jiangxi; three stage DEA model; production factor input; technical efficiency

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DEA BCC

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DEA 2 : SFA 。 2

SFA

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SFA   :

$$s_{ik} = f^i(z^k; \beta^i) + v_{ik} + u_{ik} \qquad (1)$$

: $i = 1\ 2\ \cdots\ n$ 。 s_{ik} k i

            ; $z^k = (z^{1k}\ z^{2k}\ \cdots\ z^{pk})$ p

β^i ; $f^i(z^k;$

$\beta^i)$ s_{ik} ; v_{ik}

$$v_{ik} \sim N(0\ \sigma_{v_i}^2) ; u_{ik}$$

$$u_{ik} \sim N(u_i\ \sigma_{u_i}^2) ; v_{ik} \qquad u_{ik}$$

。 $r = \dfrac{\sigma_{u_i}^2}{\sigma^2} (\qquad \sigma^2 = \sigma_{u_i}^2 + \sigma_{v_i}^2) \qquad r$

1   ; r

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$$\hat{x}_{ik} = x_{ik} + \max_k\{z_k\beta^i\} - z_k\beta^i +$$
$$\max_k\{\hat{v}_{ik}\} - v_{ik} \qquad (2)$$

: $i = 1\ 2\ \cdots\ m$; $k = 1\ 2\ \cdots\ n$ 。 x_{ik} k

              i $\hat{x}_{ik}$

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表1   **Pearson**   [①]

Tab.1 Pearson correlation coefficient of Households'
input and output variables

Output	Commercial forest area	Labor	Investment
Income of forestry	0.254 *** (0.000)	0.177 *** (0.001)	0.362 *** (0.000)

①* ** ***   10% 5% 1%   ;
        P 。 Figures in the parentheses are P statistic values; * ** and *** denote 10% 5% and 1% levels of significance respectively.

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Tab. 2   Values of environment variables and statistical description

Environment variables	Explanation	Mean	Standard deviation
Age of household head /a X_1	Age	49. 55	9. 83
Education level of household head /a X_2	School years	6. 72	2. 70
Percentage of non-farm income to total income（％） X_3	2007 2011 / Percentage of non-farm income to household's total income	0. 74	0. 26
Forestland slope X_4	1: ＜15°; 2: ＞15°&＜25°; 3: ＞25°	1. 30	0. 64
Distance from forestland to road/km X_5	Average distance from forestland to road	2. 04	1. 61
Annual average precipitation/mm X_6	2007 2011 Annual average precipitation of sample county from 2007 to 2011	1 651. 61	130. 56
Annual average temperature/℃ X_7	2007 2011 Annual average temperature of sample county from 2007 to 2011	18. 33	1. 13
Certificate acquisition of forestry property right X_8	1 = 0 = 1 = yes 0 = No	0. 92	0. 11
Logging quota application X_9	1 = 0 = 1 = Easy 0 = No easy	0. 63	0. 48
Forestry tax X_{10}	1 = 0 = 1 = Decrease 0 = No decrease	0. 60	0. 49
Forestland plots X_{11}	Operating forestland plots	4. 64	3. 59
Forestry technology education & training X_{12}	1 = 0 = 1 = yes 0 = No	0. 57	0. 44
Financing service X_{13}	1 = 0 = 1 = yes 0 = No	0. 12	0. 47
Providing market information service of forest product supply and demand X_{14}	1 = 0 = 1 = yes 0 = No	0. 58	0. 49
Forest product market price X_{15}	2007—2011 Average price index of forest product	143. 32	24. 79

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3 2007—2011

Tab. 3 Households' output and input per hectare of different operational types during 2007—2011

Operational types	Output/(yuan·hm⁻²)		Area/hm²		Labor/(d·hm⁻²)		Investment/(yuan·hm⁻²)		Percentage (%)
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Timber forest TF	3 792.90	443.43	1 099.05	143.6	10.35	0.98	326.85	40.1	11.04
Bamboo forest BF	2 510.40	576.12	554.70	40.39	18.00	0.98	243.00	45.36	37.12
Economic forest EF	5 115.45	380.21	268.95	21.82	40.05	2.68	1 241.10	93.93	14.72
Timber with bamboo forest TBF	1 552.95	104.53	1 198.50	84.05	18.75	1.07	275.10	31.3	23.00
Bamboo with economic forest BEF	3 807.90	416.47	474.75	26.12	40.05	2.60	1 028.10	104.37	7.36
Fuel wood with bamboo forest FBF	767.70	142.40	999.45	32.89	12.00	0.75	413.25	164.85	6.76

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Tab. 4 The production technical efficiency(TE) pure technical efficiency(PTE) and scale efficiency(SE) of household's operational types during 2007—2011 in the first stage

Operational types	TE1		PTE1		SE1	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
TF	0.369 4	0.117 0	0.695 3	0.452 4	0.531 3	0.248 4
BF	0.343 3	0.109 8	0.743 0	0.201 3	0.462 1	0.178 0
EF	0.402 9	0.136 7	0.810 1	0.156 7	0.497 4	0.210 1
TBF	0.315 1	0.084 5	0.462 3	0.098 5	0.681 7	0.149 8
EF	0.169 5	0.106 9	0.406 0	0.127 5	0.417 4	0.191 6
FBF	0.218 6	0.031 8	0.420 0	0.084 3	0.520 4	0.199 9
Mean	0.284 4	0.109 4	0.573 4	0.284 5	0.496 1	0.116 5

①TE1 1 PTE1 1 SE1 1 TE1 = PTE1 × SE1。 TE1 denotes the production technical efficiency PTE1 denotes the pure technical efficiency and SE1 denotes the scale efficiency in the first stage.

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表 5　2　　SFA[①]

Tab. 5　Regression results of SFA in the second stage

	Slack variable of area	Slack variable of labor	Slack variable of investment
Constant	5. 24(−2. 86)***	−10. 35(2. 34)**	−13. 18(2. 52)***
X_1	−1. 71(−2. 23)**	−0. 81(−2. 01)**	−0. 73(−2. 26)**
X_2	−1. 12(2. 34)**	−0. 95(1. 94)*	−1. 21(2. 13)**
X_3	4. 12(3. 09)***	−4. 09(−4. 57)***	6. 34 (2. 24)**
X_4	1. 11(2. 63)***	1. 07(1. 84)*	3. 52(3. 53)***
X_5	1. 65(2. 30)**	0. 74(1. 97)**	23. 01(2. 35)**
X_6	−1. 53(−1. 97)**	−1. 81(−2. 72)***	−5. 72 (−3. 37)***
X_7	−1. 22(−3. 51)***	−1. 67(−4. 38)***	−4. 69(−2. 23)**
X_8	−4. 37(−4. 59)***	−5. 68(−6. 56)***	−7. 89 (−8. 21)***
X_9	−1. 06(−2. 44)**	−0. 16(−3. 07)***	−1. 95(−1. 78)*
X_{10}	−1. 43(−2. 58)***	−2. 79 (−3. 07)***	−1. 77(−5. 08)***
X_{11}	0. 22(0. 65)	0. 53(2. 13)**	1. 85(2. 34)**
X_{12}	−3. 05(−4. 17)***	−2. 19 (−2. 93)***	−3. 16(−5. 77)***
X_{13}	−0. 34(−1. 57)	−0. 67 (−1. 18)	−0. 15(−1. 93)*
X_{14}	−0. 15 (−1. 24)	−0. 18(−1. 32)	−0. 58(−1. 28)
X_{15}	−0. 63 (−2. 37)**	−1. 35(−3. 47)***	−1. 95(−4. 65)***
σ^2	4. 87(12. 34)***	5. 41 (2. 32)**	8. 75 (9. 33)***
r	0. 98(2. 13)**	0. 92(3. 98)***	0. 92(5. 34)***
Log likelihood	−15. 55	−12. 71	−11. 89
LR 　LR test of the one-sided error	3. 17	4. 91	7. 82

①*　**　***　　　　　　10%　5%　1%　　　　　　　；　　　　　　　　　　　　　　　　　　　　　　　　　　　　；
　　　　　　t　　。Figures are the influential extent of environment viable to output and input variable. Figures in the parentheses are t statistic values; *, ** and *** denote 10%, 5% and 1% levels of significance, respectively.

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Tab. 6   Production technical efficiency pure technical efficiency and scale efficiency of household's

operational types during 2007—2011 in the third stage

Operational types	TE3		PTE3		SE3	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
TF	0. 335 4	0. 183 1	0. 783 2	0. 236 5	0. 425 4	0. 184 7
BF	0. 255 7	0. 146 5	0. 828 7	0. 165 7	0. 291 4	0. 172 5
EF	0. 280 7	0. 056 4	0. 845 7	0. 064 7	0. 331 7	0. 058 7
TBF	0. 348 1	0. 122 1	0. 713 4	0. 195 8	0. 465 7	0. 069 8
BEF	0. 267 8	0. 058 7	0. 761 1	0. 115 4	0. 336 5	0. 088 5
FBF	0. 181 3	0. 029 3	0. 745 7	0. 086 2	0. 242 3	0. 028 9
Mean	0. 252 1	0. 092 4	0. 779 6	0. 100 2	0. 323 3	0. 098 7

①TE3   3   PTE3   3   SE3   3   。 TE3 = PTE3 × SE3。 TE3 denotes the production technical efficiency PTE3 denotes the pure technical efficiency and SE3 denotes the scale efficiency in the third stage.

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7   **Spearman** [①]

Tab. 7   Correlation coefficient of spearman between household production technical efficiency and output per capita

	Production technical efficiency		Pure technical efficiency		Scale efficiency	
	TE1	TE3	PTE1	PTE3	SE1	SE3
Forestry income	0.719 1 [***] (0.000)	0.953 4 [***] (0.000)	0.851 0 [***] (0.004)	0.966 8 [***] (0.001)	0.149 0 [***] (0.000)	0.172 3 [*] (0.000)

① * **and *** 10% 5% and 1% P 。* ** and *** denote 10% 5% and 1% levels of significance respectively. Figures in the parentheses are P values.

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54.32% 87.46% 77.55%

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-31.69% - 19.39% - 53.44% 。   ;

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132 - 141.
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149 - 157.
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Fried H O Lovell C A K Schmidt S S *et al*. 2002. Accounting for
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（责任编辑　郭广荣）

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侯建昀   刘军弟

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本文将交易成本划分为固定交易成本和可变交易成本两部分,基于比较静态分析方法求解交易成本影响农户参与市场决策的临界条件与选择集合,并用 7 省份 635 个农户调查数据予以检验。结果表明固定交易成本与可变交易成本以不同的方式影响农户市场化行为。农户预期参与市场(出售或购买) 获得的市场剩余(生产者剩余或消费者剩余) 对可变交易成本的补偿程度,是农户相机抉择出售农产品、自给自足抑或购买农产品的依据; 固定交易成本对农户市场化行为具有正向影响,且实物资产专用性的影响大于人力资本专用性,一定规模的专用性实物资产是阻碍农户进入市场的首要门槛; 可变交易成本影响农户市场参与程度,运输方式、销售地点及结算方式显著影响农户出售农产品的可行能力。

固定交易成本   可变交易成本   资产专用性   市场化行为   农户

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（Sadoulet 等 1995）。

（Takeshima 2010）。

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（Minot 1999）。

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$$MaxU = U(Q \quad H^q) \tag{1}$$

Q　　　　　　　　　　　　　　　　* ; H^q　　　　　　　　　　　、　　　　　。

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$$\sum \left(p_k^m - c_{vk}^s(H_c^s) \right) \tau_k^s \ + (p_k^m + c_{vk}^b(H_c^b) \tau_k^b) \quad S_k - c_{fk}^s(H_c^s) \tau_k^s - c_{fk}^b(H_c^b) \tau_k^b + E \geqslant 0 \tag{2}$$

p_k^m　　　　　k　　　　　　　S_k　　q_k　　　　　　　　　k

$s_k > 0$　　$\tau_k^s = 1$；　　　$s_k \leqslant 0$　　$\tau_k^b = 1$。c_{vk}^s　　c_{vk}^b

c_{fk}^s　c_{fk}^b　　　　　　　　　　　　　　　　　　　H_c^s　　　　c_{vk}^s、c_{fk}^s　　　　H_c^b

c_{vk}^b、c_{fk}^b　　　　　　。(2)

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$$G = G(q \quad I \quad H^z \quad M \quad \Omega) \tag{3}$$

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　　　　；M　　　　　　　　　　　　　；Ω　　　　　　　、　　　　　。

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$$q_k - I_k + A_k - S_k - Q_k = 0 \quad k = 1 \quad \cdots \quad N \tag{4}$$

A_k　　　　　　　　　　k　　　Q_k　　　　　　k　　　。

　　　　k　　　q_k、　　X_k　　　Q_k　　　0　　　　　　　　　　　　　(4)

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$$Q_k \quad q_k \quad X_k \geqslant 0 \tag{5}$$

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$$L = U(C \quad H^c) + \sum_{k=1}^{N} \eta_k (q_k - X_k + A_k - S_k - Q_k) + \varphi(q \quad I \quad H^z \quad M \quad \Omega)$$

$$+ \lambda \sum_{k=1}^{N} [(p_k^m - c_{vk}^s(H_t^s)) \tau_k^s + p_k^m + c_{vk}^b(H_c^b)) \tau_k^b] S_k - c_{fk}^s(H_t^s) \tau_k^s - c_{fk}^b(H_c^b) \tau_k^b + E \tag{6}$$

　　η_k、φ　　λ　　　　　　　　　　、　　　　　　　　　　。　　　　Key

(2000)　　　(6)　　　　　　　　　　　　　：

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$$\frac{\partial U}{\partial Q_k} - \eta_k = 0 \tag{7}$$

$$\eta_k + \frac{\varphi \partial G}{\partial q_k} = 0 \tag{8}$$

$$- \eta_k + \frac{\varphi \partial G}{\partial I_k} = 0 \tag{9}$$

$$- \eta_k + \lambda \ (p_k^m - c_{vk}^s) \tau_k^s + (p_k^m + c_{vk}^b) \tau_k^b \ = 0 \quad i = \{ i \mid s_k \neq 0 \} \tag{10}$$

(2) (7) ～ (10) p_k (Selling

Decision Price) : $p_k = p_k^m - c_{vk}^s$ $s_k > 0;$ $p_k =$

$p_k^m + c_{vk}^s$ $s_k < 0;$ $\hat{p}_k = \eta_k / \lambda$

$s_k = 0$。

1

p_k^m (1)。 $p_k^m \geqslant p_k$

$+ c_{vk}^s$

。 $p_k^m \leqslant p_k - c_{vk}^s$

; $p_k - c_{vk}^s < p_m^m < p_k + c_{vk}^s$

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。 :

$$\Pr(Y > 0) \ = f_i(X_i \ c_{fk}^s \ c_{vk}^s) \tag{11}$$

Y 0 ～ 1 Y 。

。 Q_i^m。

Q_i^m :

$$Q_i^m = \beta X_i + \gamma c_{vk}^s + \varepsilon_i \tag{12}$$

— 28 —

$$Q_i^m \qquad \theta X_i + \kappa c_{fk}^s + \gamma c_{vk}^s + \eta_i > 0 \tag{13}$$

$$Corr(\varepsilon_i \ \eta_i) = \rho \neq 0 \tag{14}$$

(12) ~ (14)   Heckman

      (2011)

$Y > 0$ OLS   Heckman   。   Azam   ①

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        "   " (Bairoch 1988) 。

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① Md Shafiul Azam Katsushi Imai Raghav Gaiha. 2012. Agricultural Supply Response and Smallholders Market Participation: the Case of Cambodia. The University of Manchester Economics Discussion Paper Series EDP – 1208

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            2012   3—6   7

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《   》   122   。   53

            25   、   14   、   14   ;   69   28

、   18   、   20   、   3   ②。   (PPS

)   15   ;   PPS   3

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96. 38%	2	。

1

assetspe	( )	+
agriyear	( )	+
distance	( )	−
*tran*1	(= 1; = 0)	+
*tran*2	(= 1; = 0)	+
*tran*3	(= 1; = 0)	−
*tran*4	(= 1; = 0)	−
*tran*5	(= 1; = 0)	−
*salessit*1	(= 1; = 0)	+
*salessit*2	(= 1; = 0)	+
*salessit*3	(= 1; = 0)	+
*salessit*4	(= 1; = 0)	+
payment	(1 = ; 2 = 、 ; 3 =)	—
laborprice	(/ •)	−
apprice	(/)	+
broker	( )	+
headage	( )	?
headedu	(1 = ; 2 = ; 3 = ; 4 = ; 5 =)	?
agrlabor	( )	+
land	( )	+
cooperate	(= 1; = 0)	+

(   )

: (1)   。55. 91%
8   20   10. 87%。(2)   。
46. 38   50. 61 。(3)   。《
》   40%   。

表2

( )	91	90	91	91	91	89	92
(%)	14. 33	14. 17	14. 33	14. 33	14. 33	14. 01	14. 49

表3

		( )	(%)
( )	8	348	54. 80
	8～20	218	34. 33
	20	69	10. 87
( )	2	46	7. 24
	2～4	547	86. 14
	5	42	6. 61
( )	40	69	10. 87
	40～60	445	70. 08
	60	121	19. 06
		14	2. 20
		113	17. 80
		353	55. 59
	/	150	23. 62
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　　　OLS　　　Heckman　　　　　　　　　　　　　。　　　　　　　OLS
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	4	
	1	2
assetspe	0.0615 *** (3.27)	0.0574 *** (3.39)
agriyear	0.0141 *** (2.98)	0.0093 ** (2.17)
distance	0.0356(0.78)	0.0373(0.91)
*tran*1	−0.1981(−0.78)	−0.1354(−0.59)
*tran*2	−0.2111(−1.15)	−0.1552(−0.94)
*tran*3	−0.5928 ** (−2.48)	−0.5057 ** (−2.34)
*tran*4	−0.3772(−0.79)	−0.2800(−0.65)
*tran*5	−0.2516 * (−1.82)	−0.2072 * (−1.66)
*salessit*1	0.3207(1.58)	0.1764(0.96)
*salessit*2	0.1907(1.23)	0.0355(0.25)
*salessit*3	0.1354(0.86)	0.0122(0.09)
*salessit*4	−0.4683 *** (−2.76)	−0.2939 * (−1.92)
payment	0.1036 ** (2.21)	0.0953 ** (2.25)
laborprice	0.0068 *** (4.73)	0.0059 *** (4.55)
apprice	−0.0096(−0.2)	0.0252(0.58)
broker	0.0090 *** (3.68)	0.0072 *** (3.26)
Headage	−0.0125 *** (−3.77)	−0.0105 *** (−3.52)
headedu	0.0529(1.27)	0.0649 * (1.72)
agrlabor	0.1329 *** (2.74)	0.1356 *** (3.1)
land	0.0336 *** (7.38)	0.0381 *** (9.3)
cooperate	0.1731 *** (2.58)	0.1607 *** (2.66)

: t ; *** 、** 、* 1% 、5% 10%

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17.　　　　　　.　　　　　　　　　　　—— 7 124　　　　　　　　.　　　　　　2013
（7）:56～64

18.　　　　.　　　　　.　　　　　2011:245～247

19.　　　　　　.　　　　、　　　　　　　.　　　　　2008(7):10～14

20.　　　.　　　　.　　　2003:27～64

21.　　　　　　.　　　　　　　　　—— 　　　　　　　.　　　　2011
（6）:12～21

<div align="right">张　宁</div>

* 1

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李　韬　罗剑朝　陈　妍

(712100)

本文基于山东省泰安市 171 个农户 5 年借贷行为的调查,采用补充双对数模型和截断泊松回归模型,对农户是否从正规金融机构获得贷款以及获贷成功笔数的影响因素进行了分析。结果表明,相对于老年农户家庭,中年农户家庭更容易获得正规金融机构的贷款;农户承包土地规模越大,到正规金融机构的交通越便利,5 年内越容易获得金融机构的贷款;中老年农户家庭相对于老年农户家庭,其获得多笔贷款的概率显著降低。在此基础上,本文提出要实现金融业与农地流转对接以及加强农村交通设施建设的政策建议。
农户　正规融资　获贷笔数　泊松门栏模型

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。2011   31023
5. 33%   83. 3%   16. 7%** 2 。
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(2002)、   (2005)、   (2007)、   (2012);   、
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(2004)、   (2005)、   (2005)、
(2011)。

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171   2006—2010
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5 (2006—2010)

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220 、

171 。

表1 2006—2010

		(%)
0	84	49. 13
1	57	33. 33
2	19	11. 11
3	8	4. 68
4	2	1. 17
5	1	0. 58
	171	100

1 2006—2010 。 171

49. 13% 33. 33% 11. 11%

1 2 3 5% 。

(Count Data) 5

171 (0. 77)

(0. 94) (Poisson

Distribution) 。

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(5) i

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$(C_i = 1)$

：

$$\underset{c_i = 0, 1}{Max EU} \quad (1 - c_i)(- b_F) + c_i \underset{S > 0}{Max}(EU_S - b_S) \qquad S = 1, 2, \ldots N \qquad (1)$$

EU_S 　　　 i 　 S 　　　　　　　　　　　　 b_s 　　　 S 　　　　　　　　　　　　　　　　　 b_F

。

（1） 　　 $Max(EU_s - b_s)$

（b_F） 　　　　　　（ Max EU）

。 　　　　　　　　　　　 （1）

———

。

（1） 　　　 i

i 　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　。

`　　　　　　　　　　 `

。 　　　　　　　　　　 i 　　　　　　　　（ $C_i = 0$ 　 $C_i = 1$）

（S） 　　　　　　　　　 z 　 x 　　　　　　　　　　　　　 ：

$$c_i = h(\gamma' z, \varepsilon_{c_i}) \qquad\qquad (2)$$

$$S = g(\beta' x, \varepsilon_s) \qquad\qquad (3)$$

（2） 　（3） 　 γ' 　 β' 　　　　　　　 z 　 x 　　　　　 ε_{c_i} 　 ε_S

（C_i） 　　　　　（S） 　　　　 。 　　　　　　　 （2） 　（3）

z 　 x 　　　　　　　　　　　　 5

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z 　 x 　　　　　　　　　　　　　　　　　　　`

z 　 x

（2） 　（3） 　　　　　　　　　　　　　　　　 。 　　　　　　　　 （2） 　（3）

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" " 　　　　　　　（ Data Truncation） 　　　　　　　　　　　　 :

i 　　　　　　　　　　　　　　　　　（ C_i）; 　　　 i

（S）。 　　　 " " （ S =

— 44 —

0）　"　　　"　（　　S = 1　2　…　N）　　　　　　　　　　　　　　　　　　　　　　　　　　　probit　　logit
（Complementary log-log Model）　　　　　　　i
　　　　　　　　"　"　　　"　"　　　　　　　　　　　　　　　　　　　（Green　2011）。

（Truncated Poisson Regression Model）　　　　。

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　（$c_i = 0$）　　　　$S = 0$;
　　　$c_i = 1$　　　　$S > 0$。　　　　　　　　$C_i = 0$　　　　$P(C_i = 0)$;　　　　$C_i = 1$　　　　$P(c_i = 1) \cdot f$
$(S/c_i = 1) = P(c_i = 1) \cdot f(S > 0)$　　　　$P(\cdot)$　　　　　　　　$f(\cdot)$　　　　　　　。
　　　　　　　　　　　　　　　　　　　　　　　　　　　（C_i）　　　　　　　　：

$$P(C_i = 0) = e^{-exp(\gamma' z)} \tag{4}$$

$$P(C_i = 1) = 1 - e^{-exp(\gamma' z)} \tag{5}$$

　　（4）　　（5）　z　　　　　　　　i
　　　　　　　　　　　　　　　　（$c_i = 1$）　　　　　　　　　　（$S > 0$）
　　　：

$$P(S \mid S > 0) = \frac{P(S)}{P(S > 0)} = \frac{e^{-exp(\beta' x)}(\beta' x)^S}{S! \quad 1 - e^{-exp(\beta' x)}} \quad S = 1 \ 2 \ \dots \ N \tag{6}$$

　　　　　　　：

$$InL = \sum_{c_i = 0}(-e^{\gamma' z}) + \sum_{S > 0}\{ In(1 - e^{-exp(\gamma' z)}) - e^{\beta' x} + S\beta' x - InS! - In(1 - e^{-exp(\beta' x)}) \}$$

$$S = 1 \ 2 \ \dots \ N \tag{7}$$

　　（7）　　　　　　　　　　　（Mullahy　1986）　　　　　　　　　　　　　　　　　（Poisson Hur-
dle Model）　　　　　　　　　（7）

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1.　　　　　　。　　　　　　　　　2006—2010

(18 ~ 35　　　youngh)　　　　　(36 ~ 45　　middleh)　　　　　　(46 ~ 55　　mid-oldh)　　　　　　(56

oldh)　　　　　　　　　　　　　　　　　　　　3　　　　　　。

。

2.　　　　　　　(gender)

(Fletschner　　2011) 。

。

3.　　　　　　　　(education)　　　　　　　　　　　　　　　　。

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4.　　　　　　　　　　　(land) 。

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5.　　　　　　　　　　　　　　　(traffic) 。

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6.　　　　　　　。　　　　　　　　　　5

(farm) 、　　(nonfarm)　　　(bothtype)

2　　　　　。

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5　　　　　　　　　　　　　　　　　　3

(　　4) 。

(2007)

(　　　　36　　　　　　　　　　　)

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<table>
<thead>
<tr><th colspan="5">2 、</th></tr>
</thead>
<tbody>
<tr><td>count</td><td></td><td>0. 77</td><td>0. 97</td><td>171</td></tr>
<tr><td>gender</td><td>(= 1 = 0)</td><td>0. 44</td><td>0. 50</td><td>171</td></tr>
<tr><td>youngh</td><td>(= 1 = 0)</td><td>0. 09</td><td>0. 29</td><td>171</td></tr>
<tr><td>middleh</td><td>(= 1 = 0)</td><td>0. 43</td><td>0. 50</td><td>171</td></tr>
<tr><td>mid-oldh</td><td>(= 1 = 0)</td><td>0. 32</td><td>0. 47</td><td>171</td></tr>
<tr><td>land</td><td>( )</td><td>1. 75</td><td>1. 54</td><td>171</td></tr>
<tr><td>education</td><td>( )</td><td>8. 86</td><td>3. 14</td><td>171</td></tr>
<tr><td>traffic</td><td>(= 1 = 0)</td><td>0. 46</td><td>0. 50</td><td>171</td></tr>
<tr><td>farm</td><td>(= 1 = 0)</td><td>0. 39</td><td>0. 49</td><td>171</td></tr>
<tr><td>bothfarm</td><td>(= 1 = 0)</td><td>0. 52</td><td>0. 50</td><td>171</td></tr>
</tbody>
</table>

(land) 5

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(2004) 、 (2005)

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	1: (cloglog model)	2: (truncated Poisson model)
	(: count)	(: count)
gender	−0.0172(0.3030)	−0.0955(0.3198)
youngth	0.9071(0.5972)	−0.5240(0.5530)
midh	0.9600**(0.4719)	−0.4752(0.3989)
midoldh	−0.6521(0.4748)	−1.0949**(0.4842)
land	0.5131***(0.1243)	0.0029(0.1546)
education	0.0565(0.0472)	0.0754(0.0036)
traffic	1.0911***(0.3240)	0.1556(0.4094)
farm	−0.0136(0.5788)	−0.1826(0.7897)
bothfarm	0.0151(0.5898)	−0.2161(0.7933)
	−3.1546(0.7797)	−0.2063(0.7933)
	LR chi2(9) = 102.73***	LR chi2(9) = 25.19***
	Log Likelihood = −67.1383	Log Likelihood = −81.4808
	171	87

: ***、**、* 0%、5%、10% 。

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	(1)	(2)
(middleh)		
(land)		
(traffic)		
(mid-oldh)		

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4.　　　　　　.　　　　　　　　　　—— 745　　　　　　　　　　　.　　　2002 (10): 29～35

5.　　　　.　　　　　　　　　——　　　　　　　　.　　2005(8): 58～67

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11.　　　.　　　　.　2011(7): 128～141

张　宁

治理机制对小额贷款公司绩效的影响[*]

——基于 169 家小额贷款公司的实证分析

杨虎锋[1]　何广文[2]

内容提要：本文利用 169 家小额贷款公司的调查数据，分析了治理机制对小额贷款公司财务绩效和社会绩效的影响。研究发现：股东类型对小额贷款公司的财务绩效和社会绩效无显著影响；股权集中度越高，小额贷款公司的财务绩效越差，社会绩效表现越优异；较大规模的董事会不利于小额贷款公司实现良好的财务绩效，但董事会规模对社会绩效没有显著影响；外部监管和市场竞争等外部治理机制对小额贷款公司财务绩效和社会绩效的影响均不显著。因此，完善小额贷款公司的治理机制，应重点关注其内部治理机制。

关键词：小额贷款公司　治理机制　绩效

一、引言

小额贷款公司是政府为推动农村金融深化在农村金融组织体系方面实施的一项制度创新。自设立以来，小额贷款公司在努力实现自身财务可持续性的基础上，还承担着支持"三农"和微小企业的社会责任。治理机制决定着微型金融机构经营的成败（Armendáriz and Morduch，2010），良好的公司治理对小额贷款公司的可持续发展至关重要，然而，传统的公司治理机制对微型金融机构的作用有限（Hartarska，2005；Mersland and Strøm，2009）。那么，如何完善具有双重目标的小额贷款公司的治理机制，还需在理论层面和实践层面进行探索。公司治理机制可分为内部治理机制和外部治理机制，前者包括股权结构、董事会设置等，后者包括监管、市场竞争等。这些治理机制对小额贷款公司的财务绩效和社会绩效分别有怎样的影响？如何完善小额贷款公司的治理机制？回答以上问题，可对完善小额贷款公司的制度安排提供参考。本文从治理机制与绩效关系的角度，探讨小额贷款公司的股权结构、董事会设置等内部治理机制和监管、市场竞争等外部治理机制与其财务绩效和社会绩效的关系。

二、文献回顾

关于微型金融机构股权结构与绩效的关系，一种观点认为，由于缺少所有者的监督，公益性微型金融机构的治理效率相对较差（Jansson and Westley，2004）。Servin et al.（2012）分析了拉丁美洲

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315 家微型金融机构的股权结构与其技术效率的关系，发现非政府组织和合作性微型金融机构的技术效率低于非银行金融中介和银行的微型金融机构，说明股权结构对微型金融机构的技术效率有重要影响。另一种观点认为，非政府组织和商业性微型金融机构在财务绩效和社会绩效方面并无明显差异（Cull et al.，2007；Mersland and Strøm，2009）。Tchakoute-Tchuigoua（2010）通过对 202 家微型金融机构的治理机制与其绩效关系的分析，发现只有在以贷款质量作为绩效评价指标时商业性微型金融机构的绩效才优于公益性微型金融机构，并且商业性微型金融机构的社会绩效表现更为优异，因而微型金融的商业化与其实现社会目标并不矛盾。这可能与这些商业性微型金融机构的投资者主要为非政府组织、捐赠者和社会目标导向的投资者有关（Ivatury and Abrams，2005）。

董事会是治理机制的重要构成部分。Mersland and Strøm（2009）研究发现，与拥有国际董事的微型金融机构相比，拥有当地董事的微型金融机构的财务绩效更优，董事长和总经理分设更有利于提高客户覆盖面。微型金融机构管理者权利的大小与机构承担的风险负相关（Galema et al.，2012）。Hartarska（2005）通过对中东欧国家和部分新独立国家的微型金融机构的分析，发现对微型金融机构经理人基于业绩的奖励与机构的财务绩效和社会绩效的关系较小，出现目标偏离的微型金融机构实施低工资将导致覆盖面降低，经理人的经验则有利于改善微型金融机构的财务绩效和社会绩效，覆盖面和财务可持续之间的平衡依赖于董事会对利益相关者的代表性。Speckbacher（2008）认为，非盈利性微型金融机构由于缺乏股东的监督而需要大的董事会；而 Hartarska（2005）认为，董事数量与微型金融机构的财务绩效和社会绩效负相关。另外，微型金融机构的透明度对其财务绩效有显著的正向影响，这主要是因为较高的透明度有利于形成客户、员工、捐助人、投资人等对管理层的信任，进而促进绩效目标的实现（Augustine，2012）。

一般认为，市场竞争越激烈，则内部治理的重要性越小（刘芍佳、李骥，1998），但激烈的市场竞争可能会减少微型金融机构对风险较大、成本较高客户的贷款，进而降低覆盖面（Berger and Udell，1998）。Cull et al.（2009）通过对 245 家微型金融机构的分析，发现监管使得商业性微型金融机构更加追求商业利润而降低对妇女和服务成本较高客户的覆盖面，而公益性微型金融机构则更倾向于维持对妇女和服务成本较高客户的覆盖面。但是，Hartarska and Nadolnyak（2007）研究发现，监管对微型金融机构的财务绩效没有影响，对其社会绩效的影响也相对较小；Mersland and Strøm（2009）的研究得出基本相同的结论。

由以上可见，针对微型金融机构的治理机制与其绩效的关系已有不少研究，但从研究结论来看，对治理机制与绩效关系的认识还远未达成一致。另外，这些研究主要针对国外传统的微型金融机构，其结论是否适用于由纯私人资本控制的商业性微型金融机构还有待商榷。本文将尝试弥补以上不足，利用 169 家由民营企业或自然人发起设立小额贷款公司的调查数据，对商业性微型金融机构的治理机制与其绩效的关系进行研究。

三、研究设计

（一）研究假说的提出

公司治理主要关注股东与管理者、大股东与小股东的利益冲突问题（白重恩等，2005），作为兼具双重目标的微型金融机构，小额贷款公司的公司治理还应关注双重目标的协调问题。因此，考察小额贷款公司的治理机制与其绩效的关系，应从财务绩效和社会绩效两个角度进行。结合小额贷款公司的实际状况，本文主要从股权结构、董事会治理等内部治理机制和监管、市场竞争等外部治理机制的角度考察小额贷款公司的治理机制与其财务绩效和社会绩效的关系。

与个人股东相比，法人股东更有监督管理层的能力和动力，也有更强的资金实力；同时，法人股东良好的声誉也有助于小额贷款公司获得金融机构的认可，进而更易于获得外部融资。因此，法人股占比越高，小额贷款公司的财务绩效越优异。然而，无论是法人股东还是个人股东，均以追求投资回报最大化为主要目标，在追求社会绩效方面应无明显差异。由此，本文提出第一个研究假说：

假说1：法人股占比对小额贷款公司的财务绩效有正向影响，对社会绩效则无影响。

小额贷款公司的股东数量较少，股权较集中，且股东多为本地投资者，对管理层的监督成本低，股东与管理层之间信息对称程度高，委托—代理问题不突出。由此，本文提出第二个研究假说：

假说2：股权集中度对小额贷款公司的财务绩效和社会绩效无明显影响。

Hartarska（2005）认为，微型金融机构的董事会规模对其财务绩效和社会绩效有负向影响，这可能是因为小规模的董事会能够较好地发挥监督作用，而大规模的董事会更容易为管理层所控制（Jensen，1993），尤其是在公司规模较小、业务相对简单、董事背景相似的情况下，规模较小的董事会的监督效果可能更好。由此，本文提出第三个研究假说：

假说3：董事会规模对小额贷款公司的财务绩效和社会均有负向影响。

超产权论认为，公司效益与股权结构无关，而与市场竞争程度有关，竞争才是公司效益改善的根本保证（Tittenbrun，1996）。但是，竞争也会降低小额贷款公司的利率，进而降低其财务回报。激烈的市场竞争会使小额贷款公司减少发放高风险、高成本的小额贷款，进而提高覆盖深度，降低覆盖广度。由此，本文提出第四个研究假说：

假说4：市场竞争程度对小额贷款公司的财务绩效和社会绩效均有负向影响。

监管部门将小额贷款公司定位为经营小额贷款业务的公司，要求其贷款发放应坚持"小额、分散"的原则，在监管办法中也对小额贷款公司的资金运用提出了相应的要求。由于小额贷款的管理成本相对较高，因此，监管部门所要求的贷款额度越小，小额贷款公司的财务绩效越差，覆盖深度越低，覆盖广度越大。由此，本文提出第五个研究假说：

假说5：监管要求的严格程度对小额贷款公司的财务绩效有负向影响，对其社会绩效则有正向影响。

（二）模型构建与变量选择

为了检验以上理论假说，本文选择了反映小额贷款公司的财务绩效、社会绩效、股权结构、董事会、外部监管、市场竞争方面的变量，各变量的含义简要介绍如下：

1.被解释变量。本文采用资产收益率（ROA）和净资产收益率（ROE）两项指标来衡量小额贷款公司的财务绩效，该两项指标的值越高，说明小额贷款公司的财务绩效越好。对社会绩效的衡量，本文采用平均单笔贷款余额/注册地人均地区生产总值、贷款余额笔数两项指标来分别反映小额贷款公司的覆盖深度和覆盖广度，其中覆盖深度指标反映小额贷款公司的服务惠及中低收入群体的情况，该指标值越小说明小额贷款公司的贷款额度越小，其服务越能惠及中低收入群体，社会绩效表现越好；覆盖广度指标反映小额贷款公司的服务惠及客户群体的规模，该指标值越大，说明其服务惠及的客户越多，实现的社会绩效越好。

2.解释变量。本文中的解释变量主要包括四类：①股权结构变量，包括法人股占比、第一大股东身份、第一大股东持股比例、前五大股东股权集中度，其中，前五大股东股权集中度采用赫芬达尔指数来衡量；②董事会变量，包括董事长与总经理是否兼任、董事会规模两项指标；③外部监管变量，包括最低注册资本要求和小额贷款要求两项指标；④市场竞争变量，本文采用小额贷款公司所在地金融市场贷存比来反映金融市场的竞争程度。

3.控制变量。根据杨虎锋等（2011）的研究，公司规模和成立时间长度对小额贷款公司的绩效有显著影响。为了控制公司规模和成立时间长度的影响，本文引入成立时间长度和公司规模两项指标作为控制变量。上述各变量的定义见表1。

表1 变量名称与定义

变量类别	变量名称		定义
被解释变量	财务绩效	资产收益率（%）	总利润/平均总资产
		净资产收益率（%）	总利润/平均所有者权益
	社会绩效	覆盖深度	平均单笔贷款余额/注册地人均地区生产总值
		覆盖广度（笔）	贷款余额笔数
解释变量	股权结构	法人股占比（%）	法人股东出资额/注册资本
		第一大股东身份	法人=1，自然人=0
		第一大股东持股比例（%）	第一大股东出资/注册资本
		前五大股东股权集中度（%）	前五大股东股权赫芬达尔指数
	董事会	董事长和总经理是否兼任	兼任=1；未兼任=0
		董事会规模（人）	2011年年末董事会成员人数
	外部监管	最低注册资本要求（万元）	所在省（区、市）对股份制小额贷款公司注册资本的最低要求
		小额贷款要求	附加更高要求=1，否则=0
	市场竞争	贷存比（%）	所在地金融机构期末总贷款余额/总存款余额
控制变量	成立时间长度（年）		至2011年年末实际成立年数
	公司规模（万元）		2011年年末公司总资产

为检验前文提出的假说，治理机制对小额贷款公司绩效影响的计量模型可以设为：

$$Y_i = \alpha + \beta X_i + \delta Z_i + \varepsilon_i \qquad (1)$$

（1）式中，Y_i 表示样本小额贷款公司的财务绩效和社会绩效；X_i 是小额贷款公司治理机制变量的集合；Z_i 是控制变量的集合；α、β、δ 是待估计系数，ε 为随机误差项。

（三）数据来源

本文中小额贷款公司的治理机制与其绩效关系实证分析所采用的数据，来源于本课题组 2012 年 11~12 月对小额贷款公司的问卷调查。本次调查采用通过行业协会向小额贷款公司发放问卷的形式进行，调查对象为已正式对外营业且营业时间超过 1 年的小额贷款公司，调查内容包括：小额贷款公司的基本注册信息、截止到 2011 年年末基本财务状况和业务发展状况、股权结构和公司治理基本情况、所在地的经济和金融发展状况。调查范围涉及 20 个省（区、市），共获得有效样本 169 个。

四、模型估计结果与分析

（一）小额贷款公司绩效和治理结构的基本统计特征

从表 2 可以看出，在财务绩效方面，与上市商业银行相比[①]，样本小额贷款公司呈现高资产收

[①]2012 年度，国内 17 家上市商业银行的平均资产收益率为 1.23%、平均净资产收益率为 20.40%。数据来源：国内 A 股上市的 16 家商业银行的数据来源于巨潮资讯网（http://www.cninfo.com.cn），香港 H 股上市的重庆农村商业银行的数据来源于香港交易所网站（http://www.hkex.com.hk）。

益率、低净资产收益率的特征，这主要是因为小额贷款公司收取的贷款利率较高，但受《关于小额贷款公司试点的指导意见》（银监发［2008］23号）中规定的"融资余额不得超过资本净额的50%"的限制，小额贷款公司的财务杠杆较小，影响了其净资产收益率的水平。在社会绩效方面，样本小额贷款公司服务的客户主要为小微企业、个体工商户和农村大户，覆盖深度相对较高，覆盖广度相对较小。

在股权结构方面，样本小额贷款公司的法人股占比平均为58.27%，法人股构成小额贷款公司股本的主体；样本小额贷款公司中有83.43%的公司的第一大股东为法人，第一大股东持股比例平均为36.56%，前五大股东股权赫芬达尔指数平均为24.29，反映出第一大股东对公司的控制力较强，公司的股权集中度较高。在董事会构成方面，样本小额贷款公司的董事人数平均为5.75人，董事会规模相对较小，且仅有9.47%的公司由董事长兼任总经理，董事会的独立性较强。在外部监管方面，在所有公布监管办法的30个省（区、市）中，有11个省（区、市）提出的小额贷款要求严于《关于小额贷款公司试点的指导意见》（银监发［2008］23号文件）；在最低注册资本要求方面，各省（区、市）的要求均高于23号文件，其中，小额贷款公司注册为股份有限公司的，有10个省（区、市）要求其最低注册资本介于5000万～10000万元，有6个省（区、市）要求为1亿元。在外部市场竞争方面，样本小额贷款公司注册地的平均贷存比为74.71%，略高于2011年年末全部银行业金融机构70.37%的水平[①]。另外，样本小额贷款公司的平均成立时间长度为2.68年，平均资产规模为2.96亿元，反映出样本主要为经营已逐步步入正轨、资产规模相对较大的小额贷款公司。

表2　　　　　　　　　　　　　　　　　变量描述性统计

变量	最大值	最小值	均值	标准差
资产收益率（%）	22.20	-20.35	6.89	5.23
净资产收益率（%）	22.83	-32.33	9.06	7.13
覆盖深度	214.63	0.25	36.76	34.64
覆盖广度（笔）	33948	17	536.60	2725.28
法人股占比（%）	100.00	0.00	58.27	35.72
第一大股东身份	1	0	0.83	0.37
第一大股东持股比例（%）	100.00	9.80	36.56	23.33
前五大股东股权集中度（%）	100.00	4.00	24.29	25.43
董事长和总经理是否兼任	1	0	0.09	0.29
董事会规模（人）	15	1	5.75	2.39
最低注册资本要求（万元）	10000	1000	4639.05	2837.86
小额贷款要求	1	0	0.41	0.49
贷存比（%）	136.59	21.02	74.71	20.16
成立时间长度（年）	6	1	2.68	1.03
公司规模（万元）	209033.31	1022.06	29619.29	29655.62

（二）小额贷款公司治理机制与财务绩效的关系

由于第一大股东持股比例与前五大股东股权集中度的Pearson相关系数为0.974，为了避免变量间的多重共线，本文在模型中分别引入这两个变量。模型回归结果如表3所示，可以看出，模型的

整体拟合程度较好。根据模型回归结果，小额贷款公司的治理机制与其财务绩效的关系如下：

第一，法人股占比、第一大股东身份对财务绩效无显著影响，说明股东身份对小额贷款公司的财务绩效影响较小。在所有 169 家样本小额贷款公司中，单一法人股东的入股金额平均为 3263.08 万元，单一自然人股东的入股金额平均为 1018.03 万元，所有股东中入股金额超过 500 万元的股东占比为 76.33%，反映出小额贷款公司的股东中，无论是法人股东还是自然人股东，入股金额普遍较大，具有较强的经济实力，也具备较强的监督管理层的动力和能力。因此，法人股东和自然人股东对小额贷款公司财务绩效的影响没有明显差异。

表3　　　　　　　　　　小额贷款公司治理机制与财务绩效关系的回归结果

变量	资产收益率		净资产收益率	
	回归1	回归2	回归1	回归2
法人股占比	0.007（0.375）	0.010（0.537）	0.011（0.471）	0.014（0.620）
第一大股东身份	-0.826（-0.623）	-1.034（-0.785）	-1.102（-0.638）	-1.368（-0.797）
第一大股东持股比例	-0.055***（-2.792）	—	-0.078***（-3.028）	—
前五大股东股权集中度	—	-0.058***（-3.272）	—	-0.080***（-3.492）
董事长和总经理是否兼任	2.247*（1.747）	2.161*（1.694）	2.571（1.534）	2.460（1.481）
董事会规模	-0.366**（-2.110）	-0.394**（-2.290）	-0.431*（-1.907）	-0.465**（-2.079）
最低注册资本要求	0.000（0.583）	8.461E-05（0.475）	0.000（0.849）	0.000（0.751）
小额贷款要求	-0.860（-0.986）	-0.893（-1.034）	-1.083（-.952）	-1.133（-1.008）
贷存比	0.013（0.639）	0.012（0.609）	0.008（0.323）	0.007（0.287）
成立时间长度	1.032***（2.743）	1.098***（2.929）	1.605***（3.275）	1.694***（3.468）
公司规模	1.866***（3.814）	1.873***（3.866）	2.886***（4.528）	2.898***（4.591）
常数项	-10.666（-2.374）	-11.188（-2.553）	-18.832（-3.217）	-19.633（-3.439）
调整的 R^2	0.201	0.215	0.271	0.284
F 值	4.853***	5.191***	6.676***	7.057***

注：圆括弧内的数字为 t 统计值，*、**、***分别表示估计结果在10%、5%、1%的统计水平上显著。

第二，第一大股东持股比例、前五大股东股权集中度对财务绩效有显著的负向影响，说明股权集中度越高，小额贷款公司的财务绩效越差。这主要是因为：首先，小额贷款公司的贷款主要为"关系型"贷款，而股权集中度高的小额贷款公司，股东数量相对较少，可动用的股东关系资源少，进而股权集中度会对小额贷款公司的财务绩效造成负向影响。其次，股权集中度越高，股东对小额贷款公司的控制力越强，干预贷款投向的可能性越大，进而影响小额贷款公司的财务绩效。各省（区、市）对小额贷款公司股东的最高持股比例做出了限定性规定，以防止股权过度集中，但实践中持股比例限制逐步被突破，从而对小额贷款公司的财务绩效产生负向影响。

第三，董事长和总经理是否兼任对财务绩效有显著的正向影响，董事会规模对财务绩效有显著的负向影响，说明董事会的独立性越弱、规模越小，小额贷款公司的财务绩效越好。这主要是因为独立性较弱的董事会，其决策效率更高，更容易实现良好的财务绩效；小规模的董事会能够更有效的对管理层进行的监督。

第四，最低注册资本要求和小额贷款要求两个变量均对财务绩效无显著影响，说明外部监管对小额贷款公司的财务绩效影响较小。由于不吸收公众存款，监管部门对小额贷款公司采取非审慎监管，因此，各项监管要求所设定的条件相对宽松，对小额贷款公司经营的影响相对较小。

第五，所在地贷存比对财务绩效无显著影响，说明所在地金融市场竞争程度对小额贷款公司的影响还未显现。在广大县域内金融市场上普遍存在严重的金融资源供给不足的问题，微小企业和农户受到正规金融机构的信贷排斥，小额贷款公司面临广阔的市场空间，但在公司数量和规模相对较小的情况下，小额贷款公司还不会与其他金融机构之间产生明显的竞争。因此，小额贷款公司受到金融市场竞争的影响相对较小。

第六，公司成立时间长度和公司规模均对财务绩效有显著的正向影响，说明成立时间越长、规模越大的小额贷款公司，其财务绩效表现越好。随着小额贷款公司成立时间的延长，它对市场的了解程度、风险控制能力以及员工的经验都会得到提升，从而其财务绩效得到改善。现阶段小额贷款公司规模普遍较小，多处于规模报酬递增阶段（杨虎锋、何广文，2011），因此，规模较大的小额贷款公司，具备一定的规模经济优势，其财务绩效也相对更优异。

（三）小额贷款公司治理机制与社会绩效的关系

与财务绩效分析部分相同，为避免由于第一大股东持股比例与前五大股东股权集中度两个变量间存在的多重共线性对模型估计结果的影响，这一部分也分别将这两个变量引入模型。关于变量进入模型形式的选择，通过比较发现，当被解释变量和解释变量最低注册资本要求、公司规模采用对数形式时，模型的解释力最强，因此，上述变量以对数形式进入模型。模型回归结果如表4所示。根据模型回归结果，小额贷款公司治理机制与社会绩效的关系如下：

表4　　　　　　　　　　小额贷款公司治理机制与社会绩效关系的回归结果

变量	覆盖深度（对数）		覆盖广度（对数）	
	回归1	回归2	回归1	回归2
法人股占比	0.001（0.395）	0.002（0.476）	-0.005（-1.610）	-0.006*（-1.721）
第一大股东身份	0.227（0.876）	0.193（0.746）	-0.022（-0.091）	0.011（0.045）
第一大股东持股比例	-0.014***（-3.599）	—	0.012***（3.476）	—
前五大股东股权集中度	—	-0.013***（-3.880）	—	0.012***（3.778）
董事长和总经理是否兼任	0.044（0.179）	0.027（0.110）	0.118（0.515）	0.134（0.589）
董事会规模	-0.008（-0.252）	-0.012（-0.353）	0.011（0.340）	0.014（0.449）
最低注册资本要求	-0.146（-1.058）	-0.166（-1.207）	0.271**（2.118）	0.291**（2.274）
小额贷款要求	0.046（0.278）	0.042（0.251）	0.029（0.184）	0.003（0.211）
贷存比	0.000（0.112）	0.000（0.033）	-0.004（0.328）	-0.003（-0.908）
成立时间长度	-0.321***（-4.429）	-0.309***（-4.273）	0.351***（5.202）	0.340***（5.050）
公司规模	0.196***（2.067）	0.201***（2.141）	0.636***（7.242）	0.631***（7.239）
常数项	3.579（2.717）	3.546（2.746）	-4.353（-3.557）	-4.337（-3.615）
调整的 R^2	0.165	0.176	0.495	0.502
F值	4.329***	4.576***	17.478***	17.907***

注：圆括弧内的数字为t统计值，*、**、***分别表示在10%、5%、1%的统计水平上显著。

第一，法人股占比、第一大股东身份对覆盖深度无显著影响，说明股东身份构成对小额贷款公司的市场定位影响较小。无论是自然人股东还是法人股东，其入股小额贷款公司的主要目的均为获取投资收益，法人股东和自然人股东对小额贷款公司市场定位的影响无明显差异。另外，法人股占比对覆盖广度存在负向影响，只是在第一个回归中影响不显著，在第二个回归中影响显著，说明法人股占比高的小额贷款公司，其覆盖广度可能更小，法人股东更倾向于追求减少小额贷款公司服务

的客户数量。

第二，第一大股东持股比例、前五大股东股权集中度对覆盖深度有显著的负向影响，对覆盖广度有显著的正向影响，说明股权越集中，小额贷款公司发放贷款的额度越小、笔数越多，所服务的客户群体收入水平越低，所服务的客户数量越多，社会绩效越好。这可能是由于股权集中度越高，股东的责任越明确，为了维护自身的社会声誉，股东需要小额贷款公司履行一定的社会责任。另外，股东数量较少的小额贷款公司更容易受到监管部门的影响，而监管部门更倾向于引导小额贷款公司实现良好的社会绩效。

第三，董事会规模、董事长和总经理是否兼任对覆盖深度和覆盖广度均无显著影响，说明董事会规模是大是小以及董事会是否独立对小额贷款公司社会绩效的影响没有明显的差异。根据在调查中了解到的情况，小额贷款公司的董事主要为股东和管理层，董事会中没有代表客户利益的董事。在这种情况下，董事会规模和董事会的独立性对小额贷款公司的社会绩效不会产生明显的影响。

第四，最低注册资本要求对覆盖广度有显著的正向影响，而对覆盖深度无显著影响，说明对小额贷款公司最低规模的要求，有利于使其服务更多的客户，但对其客户群体的选择并无明显的影响。小额贷款要求对覆盖深度和覆盖广度均无显著影响，说明该项政策要求并未对小额贷款公司的市场定位产生明显影响，没有能够有效发挥引导小额贷款公司实现更好社会绩效的作用。

第五，所在地贷存比对覆盖深度和覆盖广度均无显著影响，说明在广阔的市场需求条件下，小额贷款公司还没有出现因为面临市场竞争的压力，而被迫调整其市场定位的现象，其社会绩效未受到外部市场竞争环境的影响。

第六，小额贷款公司成立时间长度对覆盖深度有显著的负向影响，对覆盖广度有显著的正向影响，说明随着成立时间长度的增加，小额贷款公司有客户群体逐渐下移、覆盖广度逐渐提高的趋势；公司规模对覆盖深度和覆盖广度均有显著的正向影响，说明规模越大的小额贷款公司，其客户群体的收入水平越高，所服务的客户数量越多。从回归结果来看，小额贷款公司覆盖深度对公司规模的弹性仅为约 0.2，而覆盖广度对公司规模的弹性大于 0.6，说明随着规模的扩大，与提高贷款额度相比，小额贷款公司更倾向于服务更多的客户。

五、结论与政策启示

小额贷款公司具有双重目标，与一般企业和商业银行在诸多方面存在差异，简单套用以往治理机制与绩效关系的研究结论有失偏颇。本文在结合小额贷款公司特点的基础上，利用 169 家小额贷款公司的调查数据，分析了包括股权结构、董事会设置、外部监管和市场竞争在内的治理机制与小额贷款公司财务绩效和社会绩效的关系。研究发现：①在股东构成方面，法人股东和自然人股东对小额贷款公司财务绩效和社会绩效的影响没有明显的差异；②股权集中度越高，小额贷款公司的财务绩效越差，而社会绩效表现越优异；③较大规模的董事会不利于小额贷款公司实现良好的财务绩效，但对社会绩效没有明显的影响；④外部监管和市场竞争等外部治理机制对小额贷款公司绩效的影响有限；⑤成立时间越长、规模越大的小额贷款公司，其绩效表现越好。

完善治理机制对改善小额贷款公司绩效有重要影响。从本文关于治理机制与小额贷款公司绩效关系的实证分析结论，可以得到如下政策启示：①在各种治理机制中，应注重小额贷款公司内部治理机制的作用；②在内部治理机制方面，应侧重于优化小额贷款公司的股权结构，防止股权过度集中或过度分散；③在股东构成方面，不应过分强调法人股东的作用；④应不断完善对小额贷款公司的外部监管，有效引导它们实现财务绩效和社会绩效的均衡提高；⑤继续深化农村金融改革，建立

适度竞争的农村金融市场。

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（责任编辑：黄纯纯）

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$$q^* = f(x \mid d \ e) \tag{2}$$

（Shephard's Lemma） ：

$$x_i = \partial c(p \ q^* \ e)/\partial p_i \tag{3}$$

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$$x_i = g_i(p \ d \ e) \tag{4}$$

$\partial x_i/\partial p_j > 0(i \neq j)$ x_i x_j ; $\partial x_i/\partial p_j < 0(i \neq j)$
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（4） ：

$$X_{it} = \alpha_0 + \alpha_1 C_{1it} + \cdots + \alpha_7 C_{7it} + \alpha_8 D_{1it} + \alpha_9 D_{2it} + \alpha_{10} P_{1it} + \cdots + \alpha_{13} P_{4it} +$$
$$\alpha_{14} E_{1it} + \cdots + \alpha_{16} E_{3it} + \alpha_{17} H_{1it} + \cdots + \alpha_{29} H_{3it} + \mu_{it} \tag{5}$$

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表3

	(N = 104)			(N = 486)		
	2009	2010	2011	2009	2010	2011
( )	49. 36	49. 38	34. 16	55. 17	68. 95	34. 94
( )	2047. 52	2078. 55	2153. 54	1621. 56	1624. 50	1705. 70
( )	95. 76	98. 05	105. 75	82. 14	85. 43	92. 33
( )	65. 99	69. 06	74. 76	54. 89	57. 73	63. 26
( )	69. 68	73. 33	79. 06	63. 15	67. 27	72. 62
( )	3837. 01	4086. 71	4337. 13	3328. 95	3036. 09	3392. 07
( )	349. 24	378. 87	414. 83	321. 70	351. 54	418. 26

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MLE　　　　　　　　　　　　　　　　　　　　　　　　　　　。　　　　　　　　GLS
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OLS	F : F(20 1265) = 14. 15; Prob > F = 0. 0000	OLS
OLS	LM : Chi2(11) = 255. 59; Prob > χ² = 0. 0000	OLS
	Hausman : Chi2(5) = 16. 39; Prob > χ² = 0. 5426	

　　　5、　6、　7、　8　　　　　　　　　　　　(　　　　　)　　　　(rho)
　　　　　　H₀　　　　　　　　　　　　　　　　　　　　　　(p <
0. 05)。　　　　　　、　　　　　　　　　　　　　　　　　　H₀
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				Z	P
	Con	3. 650***	0. 549	6. 65	0. 000
	C_2	0. 188**	0. 096	1. 95	0. 051
	C_3	0. 364***	0. 088	4. 15	0. 000
	C_4	0. 117	0. 087	1. 35	0. 176
	C_5	− 0. 064	0. 086	− 0. 75	0. 456
	C_6	− 0. 010	0. 091	− 0. 12	0. 908
	C_7	0. 031	0. 090	0. 34	0. 734
	D	− 0. 072**	0. 025	− 2. 88	0. 005
ln	P_1	− 0. 287***	0. 052	− 5. 56	0. 000
ln	P_2	− 0. 021	0. 022	− 0. 96	0. 340
ln	P_3	0. 105***	0. 023	4. 50	0. 000
ln	P_4	0. 041	0. 046	0. 88	0. 377
ln	H_1	− 0. 018	0. 033	− 0. 55	0. 581
ln	H_2	0. 243**	0. 107	2. 28	0. 023
	H_3	0. 119***	0. 046	2. 60	0. 009
ln	E_1	− 0. 395***	0. 080	− 4. 97	0. 000
ln /	E_2	0. 025	0. 072	0. 34	0. 731
ln /	E_3	− 0. 060**	0. 027	− 2. 22	0. 027
Wald chi2(17) =		313. 91			
Prob > chi2 =		0. 0000			
Rho =		0. 9942			

　　: ***、**、*　　　　　　　　1%、5%　10%

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5

7.00%。

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100.00%

28.70%。

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表6

				Z	P
	Con	3.655**	1.780	2.05	0.040
	C_2	1.101***	0.354	3.11	0.002
	C_3	−0.453	0.325	−1.39	0.163
	C_4	0.934***	0.321	2.91	0.004
	C_5	0.008	0.319	0.02	0.980
	C_6	0.804**	0.339	2.37	0.018
	C_7	0.908***	0.341	2.66	0.008
	D	0.027***	0.009	3.01	0.001
ln	P_1	0.088	0.080	1.10	0.273
ln	P_2	−0.042	0.082	−0.52	0.605
ln	P_3	0.103	0.076	1.35	0.178
ln	P_4	0.161*	0.087	1.86	0.064
ln	H_1	−0.014	0.132	−0.10	0.918
ln	H_2	0.461	0.388	1.19	0.235
	H_3	0.339**	0.173	1.96	0.050
ln	E_1	−0.354	0.291	−1.22	0.224
ln /	E_2	−0.104	0.276	−0.38	0.706
ln /	E_3	0.148**	0.060	2.47	0.014
Wald chi2(17)		97.09			
Prob > chi2		0.0000			
Rho		0.9375			

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				Z	P
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	Con	5. 512 ***	0. 733	7. 52	0. 000
	C_2	0. 577 ***	0. 176	3. 27	0. 001
	C_3	0. 117	0. 164	0. 71	0. 476
	C_4	0. 096	0. 162	0. 59	0. 552
	C_5	− 0. 213	0. 160	− 1. 33	0. 184
	C_6	0. 190	0. 168	1. 13	0. 257
	C_7	0. 551 ***	0. 166	3. 31	0. 001
	D	0. 039 ***	0. 104	2. 97	0. 001
ln	P_1	0. 041 *	0. 022	1. 91	0. 056
ln	P_2	0. 417 ***	0. 037	11. 25	0. 000
ln	P_3	0. 066	0. 052	1. 26	0. 209
ln	P_4	0. 009	0. 021	0. 44	0. 661
ln	H_1	0. 017	0. 061	0. 29	0. 775
ln	H_2	− 0. 086	0. 169	− 0. 51	0. 611
	H_3	0. 001	0. 087	0. 02	0. 988
ln	E_1	0. 458 ***	0. 141	3. 25	0. 001
ln /	E_2	0. 078	0. 137	0. 57	0. 569
ln /	E_3	0. 053 ***	0. 015	3. 58	0. 000
Wald chi2(17)		273. 60			
Prob > chi2		0. 0000			
rho		0. 9874			

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				Z	P
	Con	− 1. 127 ***	0. 403	− 2. 80	0. 005
	C_2	− 0. 169 **	0. 078	− 2. 16	0. 031
	C_3	− 0. 056	0. 072	− 0. 79	0. 432
	C_4	− 0. 130 *	0. 071	− 1. 82	0. 069
	C_5	− 0. 077	0. 070	− 1. 10	0. 272
	C_6	− 0. 082	0. 074	− 1. 12	0. 265
	C_7	− 0. 026	0. 074	− 0. 36	0. 720
	D	0. 036 ***	0. 004	− 8. 98	0. 000
ln	P_1	0. 266 ***	0. 023	11. 50	0. 000
ln	P_2	0. 006	0. 018	0. 36	0. 717
ln	P_3	0. 017	0. 018	0. 94	0. 346
ln	P_4	− 0. 312 ***	0. 979	− 3. 19	0. 001
ln	H_1	0. 002	0. 027	0. 07	0. 944
ln	H_2	0. 189 *	0. 087	2. 19	0. 029
	H_3	0. 004	0. 038	0. 11	0. 909
ln	E_1	0. 105	0. 064	1. 64	0. 101
ln　　　/	E_2	0. 053	0. 060	0. 89	0. 374
ln　　/	E_3	− 0. 097 ***	0. 017	− 5. 79	0. 000
Wald chi2(17)		209. 75			
Prob > chi2		0. 0000			
Rho		0. 8624			

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基于容积率指数和单要素DEA方法的工业用地利用效率区域差异研究

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摘要： 从土地利用无差异比较的角度出发，在阐释土地利用差异性比较的思路后，构建容积率指数（VRI）分析了不同区域工业用地利用强度变化，并消除工业产业结构对不同区域工业用地面积的影响，在此基础上利用单要素DEA方法分析了全国不同区域工业用地利用效率的特征及变化趋势。研究结果表明：VRI高的区域多分布在东南沿海地区，VRI低的区域多分布在中西部地区，并且东部地区VRI呈下降趋势；工业用地面积修正后，工业用地利用效率增大的区域多集中在中西部地区，工业用地利用效率下降的区域主要出现在东南沿海地区；以长江三角洲和珠江三角洲为主的东南沿海经济发达地区工业用地利用效率明显高于中西部地区；变异系数反映出区域间工业用地利用效率的差异程度正在逐渐缩小，工业产出的不均衡程度大于工业用地配置的不均衡程度。

关 键 词： 容积率指数；工业用地利用效率；区域差异；单要素DEA方法

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中国改革开放30余年的高速工业化进程，取得了令世人瞩目的成就，实现了由农业大国向工业大国的转变，工业化极大地带动了我国社会经济的快速发展，但长期以来支撑我国工业化发展的却是低廉的工业用地价格和粗放的用地方式。我国工业用地利用效率较低，工业用地项目容积率只有0.3~0.6，而发达国家一般是1.0[1]。2011年341个国家级开发区工业用地综合容积率仅为0.83，其中，51个开发区工业用地综合容积率在0.5以下[2]。工业化水平领先的上海市，2009年工业用地产出强度仅为30.77×10^8元/km²，与新加坡（2007年，23.29×10^8美元/km²）、伦敦（2005年，工商业用地，38.64×10^8美元/km²）、东京（2007年，$2\,489 \times 10^8$日元/km²）[3-4]等发达国家大城市相比，上海市工业用地产出效益只有它们的几分之一或十几分之一。然而，我国的快速城镇化和工业化进程还将持续较长一段时期，据预测，到2020年我国城镇化率将达58%，建设用地供需矛盾的严峻形势在短期内将难以改变[5]，而工业用地仍将是推动城镇化和工业化发展的车轮，不断提升工业用地利用效率，能为我国经济持续发展提供源源不断的动力，是解决"保障发展与保护资源"两难问题、实践科学发展观的重要举措。

目前，对工业用地利用效率的研究尚没有相对一致的方法，现有研究多从工业用地地均产出[6]、建设控制指标比较[7]、规模扩张特征[8-9]等方面进行量化，或采用集约利用评价方法[10-11]间接反映工业用地利用的效率特征。尽管也有学者采用DEA方法从不同尺度对工业用地利用效率进行研究[12-13]，但本质上分析的是区域工业生产系统的效率，不能有针对性地反映工业用地的利用程度。此外，国内外学者也深入探讨了工业用地规划[14]、出让方式与产权差异[15]、政府治理[16-17]、土地市场[18]等因素对工业用地利用效率的影响。通常产业园区内的工业用地更有效率[19]，但国内很多开发区并未表现出较高的工业用地利用效率[20]。虽然学术界普遍认为不同区域因经济发展水平和产业结构不同，土地利用水平的比较研究是应该存在差异的，但目前少有人去关注土地利用的差异性比较问题。李双异等[21]考虑到区域自然条件、经济发展水平和土地利用水平存在一定的差异，在研究中对评价因子标准值和权重在不同地区采用了不同的标准。顾湘[22]认为自然条件和经济发展造成的地区差异性是在土地利用评价中不可不考虑的问题，在研究中按照各地经济社会发展水平和土地利用水平对研究区域进行了划分。李昌峰等[23]对长江三角洲地区土地利用水平与经济发展的空间相关性研究也表明两系统存在显著的相关性。陈伟等[24]在评价工业用地利用水平时提出了产业差异修正的基本思路。鉴于此，本文在前人研究的基础上，首先解释了土地利用比较的区域差异性问题，通过构建容积率指数来反映区域间工业用地利用强度的差异，消除工业产业结构对不同区域工业用地面积的影响，然后利用单要素DEA方法进行工业用地利用效率的测度和分析。在促进工业用地区域间优化配置和利用效率提高的同时，对完善土地利用比较研究的内涵和方法也有重要意义。

1 理论与研究方法

1.1 理论阐释

严格来说，土地利用行为的比较研究可以分为两类：一类是不考虑地区或工业行业间土地利用强度差异进行的比较研究，可以称为有差异研究，另一类是考虑地区或工业行业间土地利用强度差异并进行差异消除的比较研究，可以称为无差异研究。有差异视角下的土地利用比较研究有助于掌握不同地区、不同工业行业真实的土地利用水平，能够为不同地区制定有利于节约用地、提高用地效率的产业发展政策和土地利用政策提供理论依据。无差异视角下的土地利用比较研究有助于掌握不同地区或不同行业现状可比的土地利用水平，能够为不同地区加强现状工业用地的管理提供理论依据。

当前多数学者在进行土地利用行为的比较研究时往往没有明确界定可比性的问题，多是基于有差异的比较基础展开，就土地利用的表象进行评价比较。如在比较土地利用规模和结构相似但产业结构和经济发展水平存在差异的A、B两地时（如图1，土地利用有差异比较Ⅰ），在不考虑经济发展和产业结构等条件差异影响的情况下，一般可以预期得到经济发展好的地区土地利用效果较好的结果。就地方工业经济的发展来说，受资源禀赋、经济区位、社会历史等多方面条件的影响，地方工业产业的选择并不是完全自主的。产业结构的差异也反映出不同地区在接受产业转移过程中，所处的产业梯度层次不同，经济发展好的地区产业层次相对较高，主导产业主要以高新技术、装备制造、新兴产业等为主，这些产业具有较高的土地产出能力；而经济发展较差地区产业层次相对较低，主导产业主要以纺织、食品、化工等传统行业为主，土地产出能力相对较低，但是

并不能否认经济发展较差地区实现了与产业结构相匹配的较优的土地利用状态。也就是说，不同工业行业的土地利用行为是存在差异的，土地利用行为的差异一定程度上导致了工业用地利用效率的观测差异。

在区域间土地利用行为进行无差异比较时，应具备可比的外部条件，即相同的资源禀赋状况、经济发展水平和产业结构水平。从土地利用投入的角度来说，地区经济发展水平和资源禀赋状况的差异是影

图1　区域间土地利用行为比较理论示意
Fig. 1　Theory diagram of land uses in different regions

响土地利用行为不可比的根本原因，而因产业结构差异的存在导致不同工业行业土地利用强度不同是土地利用行为不可比的直接原因，由于不同工业行业生产工艺、生产流程及生产设备的差异，在相同产出条件下必要用地量是不同的，产业结构差异的存在必然导致不同地区土地利用行为的效果不同，如产出相同的情况下，通信电子行业的必要用地量显然低于石油化工、机械制造等行业，进而有较好的土地利用效果。对不同工业行业土地利用强度进行平等考量和修正处理，应是对不同区域或不同行业进行土地利用行为无差异比较的重要前提。如在进行A、B两地土地利用行为比较时，应对产业结构等因素进行差异修正，使其达到可比条件（如图1，土地利用无差异比较Ⅱ）。

1.2　研究方法

1.2.1　容积率指数构建

基于上述理论分析，本文曾试图从工业行业角度，消除土地利用强度的行业间差异，但在省域层面缺乏分行业的工业用地统计数据，这一无差异比较研究的思路尚不可行。因此，本文尝试构建容积率指数（Volume Rate Index, VRI）来实现区域间工业用地利用强度的整体可比，并利用其将各省份工业用地实际面积换算为标准用地面积。构建容积率指数的一个重要假设是各省份的工业产出与工业用地具有匹配和对应关系，即工业产出的总量变化与工业用地的规模变化是一致的，并且区域内不同工业行业的产出规模与承载其进行工业生产的工业用地规模的变化也是相一致的。在构建容积率指数时，主要借助2008年国土资源部发布的《工业项目建设用地控制指标》，确定不同工业行业的容积率控制标准，由于各省份经济发展水平及工业生产技术存在差异，工业用地容积率控制标准应该是有区别的，但《工业项目建设用地控制指标》中没有给出容积率控制标准的区域差异修正系数，且本文较难获取到相关数据修正同一工业行业在不同区域产出能力及用地强度的差异，故所尝试建立的容积率指数未能纳入这些因素导致的土地利用强度差异影响。

1）容积率换算系数确定

首先依据《工业项目建设用地控制指标》中容积率控制标准的下限值来编制工业行业的容积率换算系数，容积率换算系数反映了不同工业行业单位土地利用面积的相对比例。利用不同工业行业与容积率控制标准之间的对应关系，可以建立工业行业间的容积率换算系数 RH_{ik}，计算公式为：
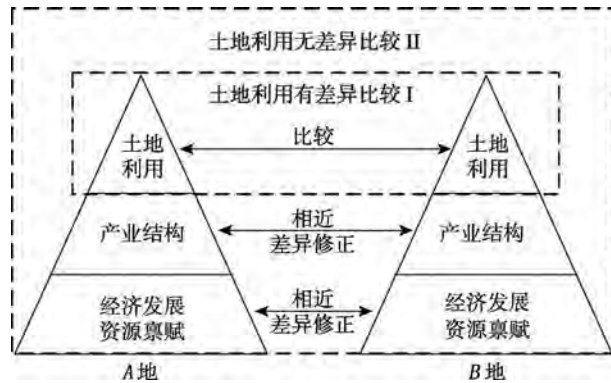
$$RH_{ik} = RL_i/RL_k \tag{1}$$

式中：RL_i 为行业 i 的容积率控制值，RL_k 为行业 k 的容积率控制值。通过计算可分别获得 30 个制造业大类行业间的容积率换算系数矩阵，通过该矩阵可以以任意大类行业为基准行业，比较得到其他行业的单位用地面积相对值。

2）容积率指数公式表达

用 ZC_{nti} 表示地区 n 第 t 年制造业大类行业 i 的工业生产总值（或工业增加值），用 m 表示地区 n 涉及的制造业行业大类数量（本文计算中，各省份 m 均等于 30），则地区 n 第 t 年的容积率指数 VRI_{nt} 可以表示为：

$$VRI_{nt} = \frac{\sum_{i=1}^{m} ZC_{nti} \times RH_{ik}}{\sum_{i=1}^{m} ZC_{nti}} \tag{2}$$

从公式（2）可以看出，本文构建的容积率指数反映了不同地区以工业产出表征的土地利用强度差异。由于基准行业 k 的选择不同，容积率换算系数的差异将直接影响容积率指数的大小。选择容积率控制标准较低的基准行业得到的容积率指数将大于选择容积率控制标准较高的基准行业得到的容积率指数。

《工业项目建设用地控制指标》中的容积率控制标准下限值介于 0.5~1.0 之间，当选择下限最大值为 1.0 的行业作为基准行业时，$VRI \in [0，1]$，当选择下限最大值为 0.5 的行业作为基准行业时，$VRI \in [0，2]$。无论选择容积率控制标准高的行业还是控制标准低的行业，VRI 越小，说明该地区工业结构整体上更偏重于土地利用强度低的行业；VRI 越大，说明该地区工业结构整体上更偏重于土地利用强度高的行业。并且，当 VRI 变大时说明该地区工业结构正在向土地利用强度高的行业转变。

当然，容积率指数主要依赖《工业项目建设用地控制指标》中确定的全国不同工业行业的容积率控制标准计算得到，而容积率控制标准仅在一段时期内起到约束作用，伴随区域社会经济的发展和生产技术的进步，容积率控制标准是逐渐提高的，容积率指数也就会随之发生变动。因此，利用本方法计算得到容积率指数不是恒定的，使用不同时期的容积率控制标准将会得到不同的容积率指数，但这并不影响容积率指数对区域工业用地利用强度的反映。

3）区域标准用地计算

标准用地面积是将各地区的实际工业用地面积根据容积率指数折合后的用地面积，是一种衡量各地区工业用地总量的可同度量的标准单位，折合后的标准用地面积消除了土地利用强度差异，可以实现不同地区工业用地的总量比较。在得到各地区 VRI 的基础上，地区 n 第 t 年的工业标准用地面积 BD_{nt} 即可表示为：

$$BD_{nt} = SD_{nt} \times VRI_{nt} \tag{3}$$

式中：SD_{nt} 即为地区 n 第 t 年的工业用地实际面积。

1.2.2　单要素 DEA 测度模型

传统的规模报酬可变（VRS）和规模报酬不变（CRS）的 DEA 模型可以从厂商（企业或农户等）角度对生产技术效率进行测度，基本原理是生产者的实际生产点偏离了生产可能性边界，从而出现效率损失。生产技术的无效率一般归结为管理无效率，而管理无效率又涉及生产投入的多种要素管理，对不同生产要素管理目标的不同将导致不同要

素效率出现差异，但从生产者技术无效率的观点出发并不能判断决定技术无效率的关键因素来自哪种生产要素的管理无效率[25]。本文研究的工业用地利用效率是在保持产出和其他生产投入要素不变的情况下，分析工业用地利用的充分程度，因此，借鉴 Speelman 等[26]进行灌溉用水效率的研究方法，利用单要素DEA测度方法有针对性地分析工业用地利用效率。

　　将每个省份看作是一个工业生产的决策单元，各省份使用相同种类的投入生产得到相同种类的产出。假设有 N 个决策单元，每个决策单元有 K 种投入和 M 种产出，对于决策单元 i 来说，用列向量 x_i 和 y_i 分别表示投入和产出。对于所有 N 个决策单元，X 表示 $K \times N$ 阶投入矩阵，Y 表示 $M \times N$ 阶产出矩阵，λ 表示一个 $N \times 1$ 的常数向量，$N(1)$ 表示元素为 1 的 $N \times 1$ 阶向量。用 θ_i^g 表示第 i 个省份的工业用地利用效率（GE）的得分变量，可通过求解下列线性规划模型得到：

$$GE_i = \min_{\theta, \lambda} \theta_i^g$$
$$\text{s.t.} \quad -y_i + Y\lambda \geq 0$$
$$\theta_i^g x_i^g - X^g \lambda \geq 0 \qquad\qquad (4)$$
$$x_i^{n-g} - X^{n-g} \lambda \geq 0$$
$$N(1)'\lambda = 1$$
$$\lambda \geq 0$$

　　公式（4）中：第一个约束条件限制决策单元 i 的产出不大于生产前沿面上的决策单元；第二个约束条件中，矩阵 x_i^g 和 X^g 仅指土地资源投入；第三个约束条件中，矩阵 x_i^{n-g} 和 X^{n-g} 是指除土地资源之外其他工业生产投入要素；第四个约束条件是一个凸约束限制，表明该模型是规模收益可变（VRS）的，如果没有这个凸约束限制，则该模型是规模收益不变（CRS）的。第二、第三个约束条件表达了在保持现有技术水平下，控制产出及其他投入要素数量不变，求取土地资源单一生产要素的效率。θ_i^g 无量纲，且 $0 < \theta_i^g \leq 1$，当 $\theta_i^g = 1$ 时，表示第 i 个省份处于生产前沿面上，是生产有效点，在不减少产出的情况下不能够减少土地资源投入数量；当 $\theta_i^g \neq 1$ 时，表示第 i 个省份不在生产前沿面上，土地资源利用无效率，理论上存在节省土地资源的可能。

2　数据来源与处理

　　为了使测算与分析结果更具现实意义和研究参考价值，基于工业生产的地区差异性分别将中国 30 个省份（不包括港澳台、西藏）抽象化为具有相同投入产出指标体系的工业生产单元。在变量选取方面，选择土地面积（G）、劳动力规模（L）和固定资本存量（C）作为工业生产投入变量，选择工业总产值（Y）作为产出变量。

2.1　数据来源

　　全国各省份工业总产值、从业人数、固定资本存量、工业用地等数据主要来源于《中国城市统计年鉴》（2002—2012 年）、《中国城市建设统计年鉴》（2001—2011 年）。全国各省份分行业工业总产值数据主要来源于各省份《统计年鉴》（2002—2012 年）。其他相关数据来源于《中国统计年鉴》（2002—2012 年）、《中国区域经济统计年鉴》（2002—2012 年）等。

2.2 数据处理

全国各省份工业总产值、从业人数、固定资本存量、工业用地等数据以2001年全国地级以上城市为基础汇总得到，未包含2002—2011年新设立的地级城市，由于部分城市数据缺失或异常，剔除了广东省深圳、阳江、东莞、揭阳、云浮5市和四川省宜宾市。此外，由于西藏设市城市仅有拉萨市，且数据缺失严重，本文在相关研究中未将西藏包含在内。因此，本文数据共涉及261个地级以上城市。其中：① 城市工业用地面积核算了全国地级以上城市市辖区工业用地面积，并汇总形成省级行政区工业用地面积。② 工业劳动力核算了地级以上城市市辖区工业年从业人员平均数，并汇总形成省级行政区工业劳动力数量，由于难以获得各城市劳动力教育水平等数据，故此数据没有包含劳动力质量上的差异。③ 固定资本存量数据参考张海洋[27]、姚志毅等[28]的方法，核算了地级以上城市市辖区工业资本净现值情况，并汇总形成省级行政区工业固定资本存量。由于难以获取到市辖区层面的工业固定资产投资价格指数，采用《中国统计年鉴》（2002—2012年）中的各省份固定资产投资价格指数，近似替代工业固定资产投资价格指数，将历年各省份工业固定资本存量统一换算到2001年价格水平。④ 工业总产值核算了地级以上城市市辖区工业总产值情况，并汇总形成省级行政区工业总产值。由于较难获取统一的工业总产值指数来构建工业总产值价格平减指数，采用《中国区域经济统计年鉴》（2002—2012年）以及历年各省份《统计年鉴》中的各省份及各地级以上城市历年工业增加值及工业增加值指数构建工业增加值价格平减指数，近似替代工业总产值价格平减指数，将历年各省份工业总产值统一换算到2001年价格水平。

3 结果与分析

3.1 容积率指数区域差异分析

本文分别设定容积率控制标准相对较低的石油加工、炼焦及核燃料加工业（容积率≥0.5）和容积率控制标准较高的通信设备、计算机及其他电子设备制造业（容积率≥1）作为基准行业，使用30个省份2001—2011年各工业大类行业的工业总产值，并结合各工业大类行业与两个基准行业的容积率换算系数，分别计算得到各省份2001—2011年的容积率指数（VRIⅠ和VRIⅡ）。

在图2中，比较了2011年全国30个省份的容积率指数，可以看出，VRIⅠ整体介于1.2~2.0之间，VRIⅡ整体介于0.6~1.0之间。2011年，VRIⅠ均值为1.491，VRIⅡ均值为0.746，其中，黑龙江（VRIⅠ=1.935，VRIⅡ=0.968）在全国处于领先地位，工业产业结构中土地利用强度高的行业占比最大，山西（VRIⅠ=1.283，VRIⅡ=0.642）工业产业结构中土地利用强度高的行业占比最小。整体来看，VRI高的省份更多地分布在我国的东南沿海地区，VRI低的省份更多地分布在我国的中西部地区，与区域经济发展水平和产业层次差异存在正相关，并且反映出我国东南沿海地区工业产业结构中土地利用强度高的行业占比整体高于中西部地区。

图3显示了全国不同区域①2001—2011年容积率指数（VRIⅠ）的变化情况。可以明显发现，2004年之前，东部地区VRI高于其他三个区域，2004年之后东北地区VRI超过

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① 东部地区包括北京、天津、河北、上海、江苏、浙江、福建、山东、广东和海南10省（市）；中部地区包括山西、安徽、江西、河南、湖北和湖南6省；西部地区包括内蒙古、广西、重庆、四川、贵州、云南、陕西、甘肃、青海、宁夏和新疆11省（市、区）；东北地区包括辽宁、吉林和黑龙江3省。
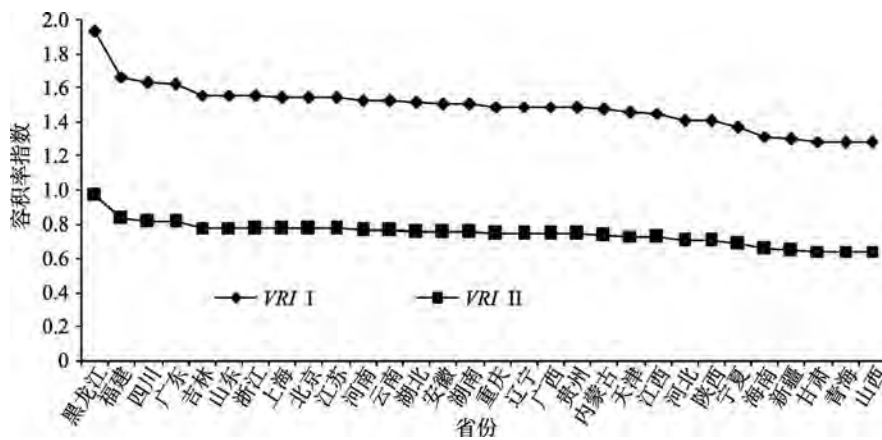
图 2 2011 年全国各省份容积率指数比较

Fig. 2 *VRI* of each province in 2011

东部地区。东部地区近些年来 *VRI* 整体表现出下降趋势，说明东部地区工业结构中土地利用强度低的行业规模占比正在逐渐增加。中部和西部地区 *VRI* 变化趋势相近，整体上呈"U"型变化，其中，中部地区 2001—2004 年处于下降状态，2004—2008 年相对稳定，2008 年后呈上升趋势；西部地区 2001—2006 年处于下降状态，2006—2008 年相对稳定，2008

图 3 2001—2011 年全国不同区域容积率指数变化（*VRI* Ⅰ）

Fig. 3 Trends of *VRI* in different regions from 2001 to 2011

年后呈上升趋势。而东北地区自 2001 年开始，基本处于稳步上升状态，地区工业结构中土地利用强度高的行业规模占比在逐渐增加。

3.2 城市工业用地利用效率区域差异分析

在进行工业用地利用效率测度之前，首先将各省份实际工业用地面积依据公式（3）并结合 3.1 节得到的 *VRI* Ⅰ 和 *VRI* Ⅱ，计算各省份标准用地面积 Ⅰ 和标准用地面积 Ⅱ。然后，分别采用工业用地实际面积、标准用地面积 Ⅰ 和标准用地面积 Ⅱ，通过编写程序代码在 GAMS 22.0 软件中实现单要素 DEA 方法工业用地利用效率的测算。本文将 DEA-CRS、DEA-VRS 模型的测度结果与单要素 SFA 方法测度结果采用 Pearson 相关系数、配对样本 *t* 检验等方法进行综合比较分析后，发现 DEA-CRS 所得结果能够更准确地反映本文研究目的，限于篇幅，具体过程不再赘述。故下文选择 DEA-CRS 模型的测度结果进行分析。

1）面积修正前后工业用地利用效率比较

在表 1 中显示了分别以工业用地实际面积、标准用地面积 Ⅰ 和标准用地面积 Ⅱ 测算的工业用地利用效率，及面积修正前后的效率变化情况。可以发现，容积率指数基准行业的选择不会对工业用地利用效率测度产生影响，主要因为本文构建的容积率指数在选

择不同基准行业时，仅反映了容积率控制指标之间的比例关系。

从表1可以看出，全国各省份工业用地利用都不充分，均不同程度地存在工业用地过度投入情况。采用标准用地面积并未导致工业用地利用效率发生剧烈变化，这也反映出在土地利用强度之外还有众多因素能够决定和影响工业用地利用效率。整体来看，采用标准用地面积后工业用地利用效率增大了0.018，但不同省份间表现出相异的变化规律，25个省份工业用地利用效率增大，5个省份工业用地利用效率下降。甘肃、新疆、山西、辽宁等省份工业用地利用效率相对提高较大，黑龙江工业用地利用效率相对下降最大。将表1中各地区工业用地利用效率按变化幅度分成四组并标示在图4中，各组划分标准为：效率增加大（0.035~0.066），效率增加较大（0.011~0.028），效率增加较小（0.005~0.010）和效率下降（-0.052~-0.001）。从图4中可以看出，工业用地利用效率增加大和较大的省份在我国中西部地区分布较为集中，而工业用地利用效率下降的省份主要出现在东南沿海地区，结合图2中各省份容积率指数分布可以发现，工业用地利用效率增加的地区恰恰多为VRI较小的地区，而工业用地利用效率下降的地区多为VRI较大的地区，由此可说明，不同地区工业用地利用强度差异确实影响了区域间工业用地利用效率的比较，并且工业用地利用效率的无差异比较方法能够在一定程度上剔除工业用地利用强度差异导致的影响，从而反映区域间相对可比的工业用地利用水平。

表1 2001—2011年全国各省份工业用地利用效率均值

Table 1 The average industrial land use efficiency of different provinces

地区	实际用地	标准用地Ⅰ	标准用地Ⅱ	修正前后效率变化	修正前后变化排序	地区	实际用地	标准用地Ⅰ	标准用地Ⅱ	修正前后效率变化	修正前后变化排序
甘肃	0.313	0.380	0.380	0.066	1	安徽	0.312	0.325	0.325	0.013	17
新疆	0.438	0.499	0.499	0.061	2	浙江	0.755	0.767	0.767	0.011	18
山西	0.233	0.288	0.288	0.056	3	江苏	0.747	0.757	0.757	0.011	19
辽宁	0.519	0.572	0.572	0.053	4	内蒙古	0.262	0.272	0.272	0.010	20
河北	0.431	0.473	0.473	0.042	5	云南	0.542	0.550	0.550	0.008	21
青海	0.188	0.225	0.225	0.037	6	河南	0.302	0.310	0.310	0.008	22
重庆	0.412	0.447	0.447	0.035	7	广西	0.249	0.257	0.257	0.007	23
吉林	0.420	0.448	0.448	0.028	8	山东	0.658	0.664	0.664	0.007	24
宁夏	0.199	0.227	0.227	0.028	9	四川	0.344	0.349	0.349	0.005	25
陕西	0.296	0.320	0.320	0.024	10	广东	0.998	0.996	0.996	-0.001	26
海南	0.839	0.861	0.861	0.022	11	北京	0.599	0.595	0.595	-0.005	27
江西	0.264	0.284	0.284	0.021	12	上海	0.898	0.889	0.889	-0.008	28
湖北	0.399	0.420	0.420	0.021	13	福建	0.897	0.888	0.888	-0.009	29
天津	0.979	0.995	0.995	0.015	14	黑龙江	0.311	0.259	0.259	-0.052	30
湖南	0.288	0.302	0.302	0.014	15	平均值	0.477	0.495	0.495	0.018	
贵州	0.204	0.218	0.218	0.013	16						

2）工业用地利用效率聚类分区分析

我国自东向西，工业用地利用效率存在较明显的区域梯度变化，并且同一区域不同省份之间也存在较大差异，为进一步了解省份间的差异特征，采用系统聚类方法，将使用标准用地面积测算得到工业用地利用效率进行区域划分。利用统计软件SPSS 20.0实现系统聚类分析，计算个体距离运用平方欧式距离方法，类间距采用组间平均连锁距离方

法来反映个体与小类间的亲疏程度。

根据聚类分析结果，将30个省份划分为3个效率区，按工业用地利用效率的高低依次是工业用地利用高效区、工业用地利用中效区和工业用地利用低效区（表2）。从测度结果的均值情况来看，三类区域的效率范围是：0.996（广东）~0.757（江苏），0.664（山东）~0.550（云南），0.499（新疆）~0.218（贵州）。在表2中，同时列出了2001—2011年工业

图4 工业用地利用效率变化幅度区域分布
Fig. 4 Regional distribution of industrial land use efficiency change

用地单要素生产率[2]均值的系统聚类分析结果，三个效率区的工业用地生产率范围分别是：56.48（天津）~34.72（山东），30.44（辽宁）~22.20（湖北），20.05（新疆）~11.02（宁夏）。

通过比较两个评价指标的聚类结果可以看出，两者之间既具有整体的相似性，也表现出一定差异，整体来看，东南沿海经济发达省份无论是工业用地利用效率还是工业用地生产率都明显领先中西部地区，中西部地区多数省份都位于工业用地利用低效区。对于工业用地来说，单要素生产率仅仅衡量了土地投入与工业产出之间的比例关系，并没有考虑其他生产要素的配合影响，不能体现技术效率的真实变化，在土地要素投入不变的情况下，工业用地生产率的提高往往是由资本、劳动等生产要素的投入变化引起的。工业用地利用效率则是在考虑全部生产要素的条件下，控制资本、劳动等生产要素及产出数量后，考察工业生产技术有效时工业用地的目标投入面积与实际投入面积之间的关系，在方法上更能反映土地要素本身的利用特征。以山东省为例，本地劳动力资源丰富，重工业基础雄厚，工业用地规模大，在众多生产要素的共同投入下，工业用地生产率聚类结果显示其位于利用高效区，但工业用地利用效率的聚类结果显示其位于利用中效区，说明在现有工业产出水平下，与工业用地利用效率高的地区相比，土地资源存在过度投入，利用效率较低。而海南省的聚类结果则显示出其工业用地单要素生产率仅处
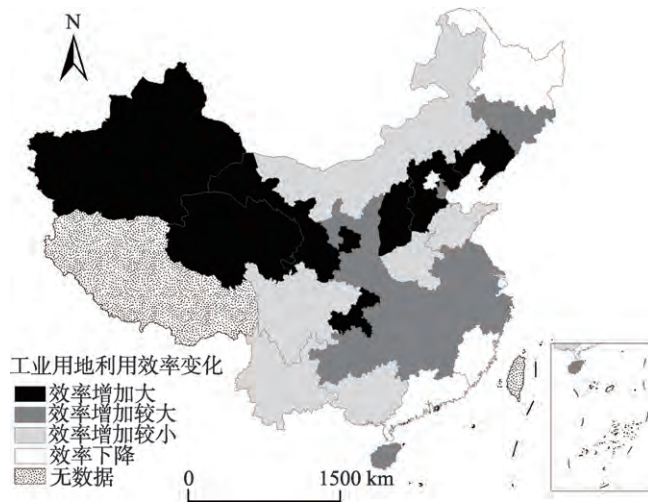
表2 工业用地利用效率与生产率聚类分区结果比较
Table 2 Clustering results of industrial land use efficiency and productivity

效率分区	工业用地利用效率	工业用地单要素生产率
工业用地利用高效区	天津、上海、江苏、浙江、福建、广东、海南	天津、江苏、浙江、福建、山东、广东
工业用地利用中效区	北京、辽宁、山东、云南	北京、河北、辽宁、吉林、上海、湖北、重庆、海南、云南
工业用地利用低效区	河北、山西、内蒙古、吉林、黑龙江、安徽、江西、河南、湖北、湖南、广西、重庆、四川、贵州、陕西、甘肃、青海、宁夏、新疆	山西、内蒙古、黑龙江、安徽、江西、河南、湖南、广西、四川、贵州、陕西、甘肃、青海、宁夏、新疆

② 单要素生产率计算公式为：工业用地单要素生产率=工业总产值/工业用地面积（10⁸元/km²）。

于利用中效区，但在现有的资本、劳动等其他要素的投入水平下，工业用地利用充分，达到了较高的利用效率。

图5显示了各省份工业用地利用效率和生产率的聚类分区情况，从图中不难看出，工业用地利用高效区均位于东部及东南部沿海地区，尤其以长江三角洲和珠江三角洲地区为主，出现这一结果是不难理解的，这些省份工业经济发达程度明显高于中西部地区，可以说这些省份处在我国工业产业梯度的最高层次，装备制造、电子通信、医药、新能源等高附加值、高技术产业发展迅速，外商投资、港澳台投资密集，工业生产技术和管理水平都非常高。此外，这些省份建设用地开发程度较高，土地资源供需矛盾尖锐，工业用地市场化水平较高。众多因素共同促使这些省份工业用地利用强度大、产出能力强，投入产出效率高。从工业用地利用效率来看，利用中效区主要包括了辽宁、山东、北京以及云南四省市，其中，辽宁、山东两省均为我国传统工业基地，工业用地规模大，重工业水平高，与长江三角洲、珠江三角洲地区的省份相比，工业用地利用效率略显不足；北京作为我国首都，也具备较强的工业基础，近年来产业转型迅速，随着第三产业的快速发展，工业规模占比逐渐缩小，但工业用地利用效率需要进一步提升；云南省是中西部地区唯一进入工业用地利用中效区的省份，尽管工业化水平较落后，但国有企业、大中型企业占比较高，在当前投入水平下，工业用地得到较充分利用。工业用地利用低效区包括了我国中西部地区的绝大多数省份，及河北、吉林、黑龙江等东部和东北地区省份。
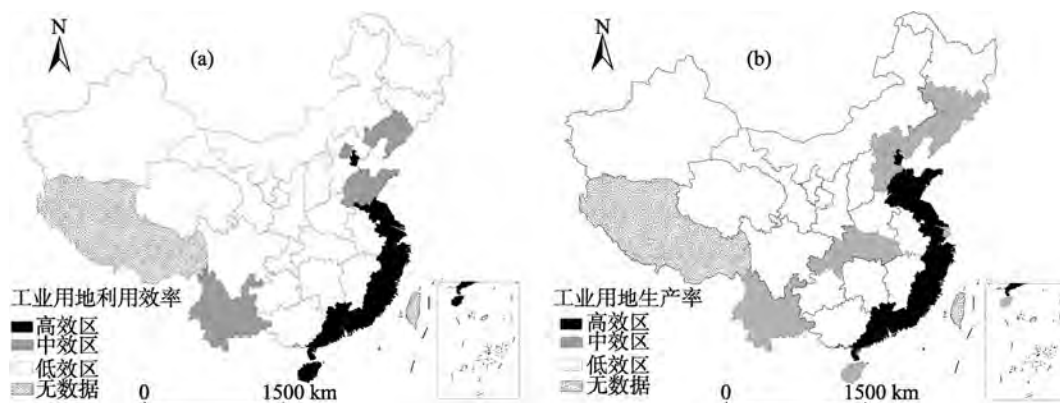

图5 工业用地利用效率与生产率聚类分区

Fig. 5 Clustering results of industrial land use efficiency and productivity

3）工业用地利用效率区域差异分析

图6(a)和(b)分别显示了不同分区方法下2001—2011年我国工业用地利用效率的变化趋势。从传统分区来看，东部地区工业用地利用效率明显高于其他三个区域，东北地区次之，中西部地区趋于一致，效率水平整体相对最低。2001—2011年各区域工业用地利用效率波幅较小，东部地区均值围绕0.8上下波动，多数年份在0.8以下，2005年效率最高，达到0.874；东北地区主要在0.4~0.5之间上下波动，2003年效率最高，达到0.521；中西部地区集中分布在0.3~0.4之间，区别较小，其波动趋势与东北地区较一致，历年均值显示西部地区略高于中部地区。从聚类分区来看，历年三个效率区的效率平均值没有交叉，具有明显的梯度差异，且离散程度较稳定。由于利用高效区与东部地区、利用低效区与中西部地区省份重合度较大，导致相关曲线表现出较一致的特征。2001—2011年
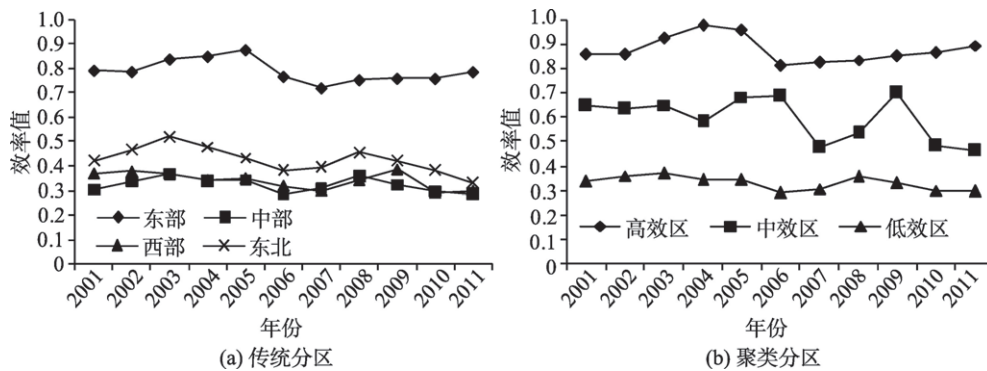
图6　2001—2011年工业用地利用效率变化趋势

Fig. 6　Trend of industrial land use efficiency by different zoning methods

各区域工业用地利用效率波幅较小，利用高效区效率均值围绕0.9上下波动，多数年份在0.9以下，2004年效率最高，达到0.979；利用中效区效率均值围绕0.6上下波动，2009年效率最高，达到0.700；利用低效区效率均值集中分布在0.3~0.4之间，波动较小，2003年效率最高，达到0.372。

为了客观反映各区域工业用地利用效率的差异水平，分别以各省份工业用地面积和工业总产值作为权重，计算各区域2001—2011年工业用地利用效率加权变异系数CV_{land}和CV_{output}。变异系数以相关区域各省份工业用地利用效率的平均值作为标准，反映相对于这个标准加权偏差的平均程度，变异系数越大，表明各省份之间效率的平均差异程度越高。由图7可见，各区域的CV_{land}和CV_{output}具有相同的变化趋势，由于利用低效区包含省份较多，导致其内部效率平均差异程度明显高于利用高效区和中效区，整体表现出差异程度不断缩小的趋势。利用高效区内部平均差异波幅较大，分别以2004和2008年为波谷和波峰振荡变化。利用中效区内部效率平均差异较小，稳定中有小幅增长。比较CV_{land}和CV_{output}同样可以看出，利用高效区和利用低效区CV_{output}值整体高于CV_{land}值，说明工业产出的不均衡程度大于工业用地配置的不均衡。
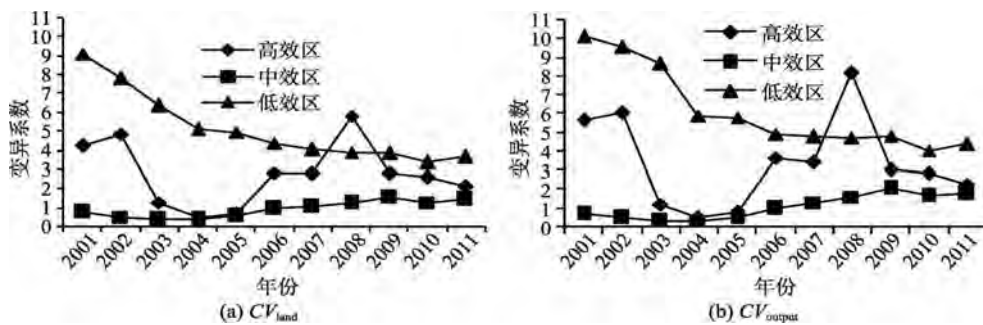

图7　2001—2011年聚类分区工业用地利用效率变异系数变化趋势

Fig. 7　Trend of the coefficient of variation for each cluster

4　结论与讨论

本文基于土地利用水平差异性比较的思想，在对差异性比较思路进行探讨后，通过

构建容积率指数来反映区域间工业用地利用强度的差异，并消除工业产业结构对不同区域工业用地面积的影响。在此基础上，借助单要素DEA方法测度和分析了全国不同区域工业用地利用效率。主要得到以下结论：

1）容积率指数能够客观反映不同地区以工业产出表征的土地利用强度差异，VRI高的省份多分布在我国的东南沿海地区，VRI低的省份多分布在我国的中西部地区，其中，黑龙江VRI最高，山西VRI最低。

2）以2004年为界，之前东部地区VRI最高，之后东北地区VRI最高；近年来东部地区VRI整体表现出下降趋势，而中西部及东北地区VRI表现出不同程度的上升趋势。

3）对工业用地实际面积进行修正后，工业用地利用效率增大的省份多集中在中西部地区，工业用地利用效率下降的省份主要出现在东南沿海地区，与VRI的高低呈负相关关系，说明VRI能够在一定程度上剔除工业用地利用强度差异对利用效率的影响。

4）以长江三角洲和珠江三角洲为主的东南沿海经济发达地区工业用地利用效率明显高于中西部地区。工业用地利用效率聚类分区与传统分区结果的一致性较高，反映出目前我国区域间工业发展具有较明显的梯度差异，自东向西工业发展水平逐渐降低。变异系数反映出区域间的差异程度正在逐渐缩小，工业产出的不均衡程度大于工业用地配置的不均衡。

本文利用容积率指数和单要素DEA方法对我国工业用地利用效率的区域差异进行了分析，所构建的容积率指数考虑了工业行业间土地利用强度差异对区域工业用地利用比较的影响，弥补了当前工业用地研究的不足，所使用的单要素DEA方法能够更加准确地反映土地要素的利用程度，所得结论将为促进工业用地区域间优化配置和利用效率提高提供重要科学参考。但所提概念及构建的研究方法仅能初步消除因土地利用强度差异导致的工业用地面积差别，并限于数据可得性等原因，未能充分考虑区域间经济发展水平、资源禀赋等的差异。土地利用无差异比较研究需要建立更全面的研究思路和方法，本文尚不能涵盖土地利用强度差异影响的所有方面，研究思路和方法均需进一步完善，建立完整的工业用地利用无差异比较方法，将有助于客观评价不同区域的工业用地利用水平。

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Regional Differences of Industrial Land Use Efficiency Based On Volume Rate Index and Sub-Factor DEA Method

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Abstract: The aims of this paper are to illustrate the meaning and method of comparing indus-trial land use efficiency in different regions by eliminating the industrial land area differences caused by industrial structures, thus to improve the level of industrial land use efficiency assess-ment. We select the land use intensity as an effective tool to eliminate the effect of industrial land area differences, and explain method of comparing industrial land use efficiency under the situation of no intensity differences. Then we build a "Volume rate index"(*VRI*) to reflect the land use intensity differences characterized by industrial output, and use it to calculate the com-parable areas of industrial land in different regions, achieving the industrial land comparison with no intensity differences. Finally, in order to grasp the full extents of industrial land use in different regions, we make 30 provinces as macro DMUs to measure the industrial land use effi-ciency using sub-factor DEA method. The data used includes industrial input and output from 2001 to 2011. The results indicate that industrial land in many provinces has not been fully uti-lized, and there is a massive waste of industrial land area. The areas which have higher *VRI* dis-tribute in southeast coastal region, and lower *VRI* areas generally locate in midwest region. Af-ter correction of industrial land area, the provinces whose industrial land use efficiency in-crease are mainly in the midwest region, and the provinces whose industrial land use efficiency decrease are mainly in the southeast coastal region. The changes of industrial land use efficien-cy and *VRI* have a negative correlation. China's industrial development has a significant region-al gradient difference, that the industrial land use efficiency in the Yangtze River Delta and Pearl River Delta are significantly higher than that in the central and western regions. The coef-ficient of variation reflects that the imbalance of industrial output is greater than the imbalance of industrial land configuration among regions, while at the same time it reflects that regional gap of land use efficiency is gradually narrowing.

Key words: volume rate index; industrial land use efficiency; regional differences; sub-factor DEA