

学校编码: 10384  
学号: 15420110153798

分类号 \_\_\_\_\_ 密级 \_\_\_\_\_  
UDC \_\_\_\_\_

廈門大學

博 士 学 位 论 文

中国省际经济与环境效率测度、比较  
及改进策略分析

Chinese Provincial Operational Efficiency and Environmental  
Efficiency Measure, Comparison and Improvement  
Strategies Analysis

章贵军

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论文提交日期: 2014年3月20日

论文答辩时间: 2014年5月20日

学位授予日期:

答辩委员会主席: \_\_\_\_\_

评阅人: \_\_\_\_\_

2014年3月



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## 摘要

建设美丽中国、实现中华民族永续发展,经济建设和环境保护二者不可偏废。为全面评价中国各省份和地区经济效率、环境效率现状以及寻求改进中国经济效率和环境效率策略,结合自然可处置和管理可处置 DEA 方法,本文主要进行了以下五个方面的研究。

1. 基于本文实证数据的对比分析表明:无论是自然可处置合成效率得分,还是管理可处置合成效率得分,径向 DEA 方法与非径向 DEA 方法均存在“因地制宜”的情况:总体而言,非径向方法测度的效率得分水平均高于径向方法;具体而言,径向方法测度的东部地区合成效率得分显著高于非径向方法,非径向方法测度的西部地区合成效率得分显著高于径向方法,中部地区两种方法测度的合成效率没有显著差异。为避免方法偏见,本文提出以加权的自然可处置合成效率和加权的可处置合成效率为依据对中国大陆 30 个省、直辖市和自治区的经济效率和环境效率进行分析,研究表明:中国东部地区经济效率和环境效率均显著高于其他两个地区;中部地区经济效率和环境效率高于西部地区。同时, Mann-Whitney-Wilcoxon 秩和检验结果表明:东部地区“十一五”期间经济效率和环境效率相对于“十五”期间无显著变化;中、西部地区“十一五”期间经济效率相对于“十五”期间显著下降,而环境效率并无显著变化。结合自然可处置和管理可处置环境管理策略,研究表明:东部地区应对更严格的环境管制机会成本相对较低,而中、西部地区为应对“十一五”期间更严格的环境管制不得不控制其经济增长的投入,从而导致经济效率显著降低。

2. 利用自然可处置非径向 DEA 方法和管理可处置非径向 DEA 方法测度的中国大陆 30 个省、直辖市和自治区 2000-2011 年的规模报酬和规模损害程度结果表明:除宁夏和青海两省可通过扩大投入规模改善经济能力外,其它省份提高经济能力的最佳策略是提高增加生产期望产品的技术和管理水平;宁夏和福建可能通过扩大投入规模提高环境能力,其它省份提高环境能力的最佳策略是改进减少有害气体排放的清洁能源技术水平和环境管理水平;对于中国经济发展和环境保护而言,总体存在投入过度的情况,改进经济能力和环境能力的最佳策略是提高生产技术和清洁能源技术水平。

3. 由于具有交互效应的径向 DEA 方法测度的自然可处置曼奎斯特合成指数

和管理可处置曼奎斯特合成指数方差偏大和与现实经济不符的情况,结合新凯恩斯主义经济周期理论,本文提出测度具有交互效应的自然可处置曼奎斯特合成指数和管理可处置曼奎斯特合成指数非径向 DEA 方法,并利用其测度中国省际自然可处置曼奎斯特合成指数和管理可处置曼奎斯特合成指数。基于非径向 DEA 方法测度的自然可处置曼奎斯特合成指数和管理可处置曼奎斯特合成指数分析结果表明:东部地区和中部地区“十一五”期间经济技术进步率与“十五”期间并无显著差异,西部期间“十一五”期间经济技术进步率下降明显;三个地区“十一五”期间环境技术进步率相对于“十五”期间变化并不明显。东部地区和中部地区可以采取更严厉的环境管制措施促进环境技术进步率提升而不会影响经济技术的改进速度,西部地区采取严格的环境管制规则应兼顾到经济技术的改进。

4. 传统的两阶段 DEA 方法要求因变量服从正态分布,鉴于测度的经济效率和环境效率常常不满足这一条件,本文构建了 DEA 方法和 Beta 回归模型相结合的两阶段 DEA 方法。在分析和比较径向方法、非径向方法和加权的方法测度的合成效率结合逻辑斯连接函数建立的 Beta 回归模型估计检验的结论后,本文得到如下相对可靠的结论和政策建议:东部地区优化产业结构和提高对外开放程度不仅有利于改进经济效率,而且有利于改进环境效率;改进中部地区经济效率关键在于优化产业结构和提高对外开放程度,改善环境效率关键在于提高科研支持度;西部地区优化调整能源结构和提升出口产品附加值和降低出口产品能耗不仅有利于改进该地区的经济效率,还有利于改进该地区的环境效率。中、西部地区由于生产技术水平、清洁能源技术水平和环境管理水平均比较落后,采取向中、西部地区倾斜性政策有利于保障全国经济与环境协调发展。

5. 由于单一 DEA 方法测度的效率中往往包含管理无效率、外部环境及统计噪声等影响因素而不能真实反映管理者的真实管理水平。传统的三阶段方法在第二阶段利用 SFA 模型分离环境影响因素。然而,由于作为因变量的松弛变量往往不服从半正态分布,从而使得环境影响因素并不能被实际分离。本文采用的三阶段 DEA 方法利用 Beta 回归模型替代传统的 SFA 模型,针对中国省际数据的分析表明,决策单位效率得分得到提高,离散程度小于单一的 DEA 模型。此外,实证研究第二阶段主要得到以下有益的结论:阐明了能源结构、产业结构、产权结构、对外开放程度、政府影响力和科研支持度等环境变量对各地区经济无效率和环境无效率的影响程度;因地制宜的提出各地区经济效率和环境效率改进措



施。第三阶段测度的纯经济效率和纯环境效率结果表明：中国大陆三个地区“十一五”期间纯经济效率得分相对于“十五”期间基本没变化；东部地区和中部地区“十一五”期间纯环境效率得分相对于“十五”期间呈现明显下降趋势，而西部地区下降不明显；三个地区采用更严格的环境管制规则并不影响经济效率，但要注意提升各地区的清洁能源技术和环境管理水平。

**关键词：** 自然可处置；管理可处置；径向 DEA；非径向 DEA；规模报酬；规模损害；曼奎斯特合成指数；Beta 回归

厦门大学博硕士论文摘要库



## Abstract

Economic development and environmental protection should be given equal emphasis in order to build beautiful China and realize sustainable development forever of Chinese nation. The major five aspects of this study as following so as to assess Chinese provisional economic development and environmental development and look for improvement strategies of operational efficiency and environmental efficiency combined with data envelopment analysis (DEA) methodology under natural disposability and managerial disposability.

1. The comparison of the unified efficiency scores are measured by radial DEA methodology and non-radial methodology under natural disposability and managerial disposability based on empirical data analysis indicate that mean value of unified efficiency scores are measured by non-radial DEA methodology higher than that of radial DEA methodology and the mean value of unified efficiency scores are measured by the radial methodology of the east in China higher than that of non-radial DEA methodology while mean value of unified efficiency scores are measured by radial methodology of the west in China lower than that of non-radial DEA methodology. This study also indicates that there are no significantly difference between the unified efficiency scores are measured by radial methodology and non-radial methodology of the central in China. This study adopts weighted unified efficiency scores of radial methodology and non-methodology to evaluate operational performance and environmental performance of three regions in China in order to avoid methodology bias and it shows that both of the operational efficiency and environmental efficiency of the east is better than the other two regions and both of them in the central is higher than the west. Meanwhile, the comparison based on Mann-Whitney-Wilcoxon rank sum test indicates that the operational efficiency and the environmental efficiency of the east shows no significantly difference between the period of “11th five-year” and “10th five-year”. The operational efficiency of the central and the west shows significantly declined during the period of “11th five-year” while there is no significantly difference between the period of “11th five-year” and “10th five-year” on environmental efficiency. The comparison combined with the environmental corporate strategy under natural disposability and managerial

disposability shows that the east with relative lower opportunity cost when facing the more stringent environmental regulation while the central and the west of China have to repress their inputs for the economic growth which leads to the operational efficiency declined significantly at that case.

2. The degree of returns to scale and damages to scale of 30 administrative regions in China during the period of 2000-2011 measured by non-radial DEA methodology under natural and managerial disposability based on the corporate strategy indicate that the optimum strategy of the most of provinces in China improve their operational performance by means of enhancement their technology level of production but Ningxia province and Qinghai province which can improve their operational performance through increasing their inputs or enhancing their technology level and management level. Many of provinces in China can improve their environmental performance by the means of enhance their clean energy technology level and environmental management level but Ningxia and Fujian which can improve their environmental performance through increasing their inputs or enhancing their clean energy technology level and management level. Overall, there exist excessive inputs which retard the improvement of operational performance and the amelioration of environmental performance, and enhancement of production technology level and clean energy technology level are the optimum strategy to improve both of them.

3. This study proposes non-radial DEA methodology to measure Malmquist unified index under natural disposability and managerial disposability of Chinese provincial regions respectively for Malmquist unified index under natural disposability and managerial based on radial methods have relative bigger variances and not consistent with economic reality. The results of Malmquist unified index measurement based on non-radial DEA methodology under natural disposability and managerial disposability indicate that the economic technology progress rates during the “tenth” Plan period of the east region and the central region of China shows no significant difference with technology progress rates during “eleventh” Plan period while economic technology progress rates of the west region significantly decline during “eleventh” Plan period. Also, environmental technology rates of three regions in China shows no significantly difference between “tenth” Plan period and “eleventh” Plan period is found in this study. Some suggestions are provided by this study, such us the east region and central region of China can adopt more stringent

environmental to prompt the promotion of the technology progress rate while doesn't impact the velocity of economic technology progress. The west region of China adopts more stringent environmental regulation should take economic technology progress into consideration.

4. This study proposes a new method combined DEA with Beta regression model for the operational efficiency and environmental efficiency can't satisfy normal distribution which traditional two-stage DEA methods dependent on. Operational efficiency and environmental efficiency combined with logit link function which used as dependent variable of Beta regression model is built in the second stage. Three main conclusions are drawn through analyzing the parameters of the Beta regression model: Optimizing industrial structure in the east region of China not only can improve the operational efficiency, but also can ameliorate environmental efficiency of that region; The most effective measure in the central region of China for improving its operational efficiency is the optimization industrial structure and promote opening up degree in this region, and the reliable measure to improve environmental efficiency is to increase expenditure for science and technology. The west region can improve its operational efficiency and environmental efficiency by the adjustment of energy structure and the enhancement of added value the reduction of energy consumption of export products. The central region and west region of China has relatively higher potentials of operational efficiency and environmental efficiency than the east region in China for their relative lower level of production technology and clean energy technology, so implement inclination policy to the central region and west region is benefit for coordination of economic development and environmental development in China.

5. Technology efficiency of single DEA methodology measurement often can't reflect the real management level of decision maker for its inclusion of "lucky" factor comes from management inefficiency, outside environment and statistical noise. Traditional three-stage methodology uses stochastic frontier analysis (SFA) model disentangle the three influences on producer performance. However, influences are not always been disentangled because of slacks which used as dependable variable doesn't follow the half normal distribution. This study analyses 30 Chinese provisional data uses three-stage DEA methodology in which Beta regression model substitute for SFA model in the second stage and the results show that efficiency scores make better than single DEA and dispersion degree also less than single DEA

model. In addition, empirical study in the second stage clarify the influence degree impose on operational inefficiency and environmental inefficiency from environmental variables such as energy structure, industry structure, ownership structure, opening up degree, government influence and science support degree. Also, this study provides measurements of the improvement of operational efficiency and environmental efficiency of three regions in China. Pure operational efficiency and pure environmental efficiency are measured in the third stage show that pure operational efficiency score in the “eleventh” plan basically as the same as the “tenth” plan and the pure environmental efficiency of the east region and the central region decline significantly in the “eleventh” while it decline slightly of the east region. Moreover, this study shows that more stringent environmental regulation doesn’t impact pure operational efficiency of the three regions but they must pay attention to improve their clean energy technology level and environmental management level.

**Key Words:** Natural Disposability; Managerial Disposability; Radial DEA; Non-radial DEA; Returns to Scale; Damages to Dscale; Malmqsite Unified Index; Beta Regression

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