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STUDY ON TFP OF GRAIN IN POYANG LAKE ECOLOGICAL ECONOMIC ZONE ON DEA

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ABSTRACT

Poyang Lake Ecological Economic Zone, a traditional rural area in Jiangxi province, whose grain production holds an important status in the pattern of food production in Jiangxi province. This paper empirically analyzes Total Factor Productivity (TFP) changes of grain in 25 counties (cities) in Poyang Lake Ecological Economic Zone by adopting DEA-Malmquist index model. The result shows that TFP of grain in Poyang Lake Ecological Economic Zone increased from 2000 to 2010 on the whole. In addition, the principal element of the increase is technological progress. Further analyzing its decomposition, it is known that the increase of TFP mainly comes from technological progress. Separately, TFP of four counties (cities) including Yongxiu county, Ruichang city, Yujiang county and Guixi city decreased while the other 21 counties' all increased. Thus, corresponding policy suggestions is put forward on this basis.

Keywords: Grain, Total factor productivity, DEA-Malmquist index model, Poyang lake ecological economic zone.

1. INTRODUCTION

Grain is the fundamental reliance of human survival and development. As it is a kind of extremely vital strategic resource, the grain issue has the direct bearing on social stability and national economic development. In the context of population growth, fast industrialization and urbanization, farmland conversion and limited farmland extension, grain production is under increasing pressure. Hence, how to optimize the disposition rationally, coordinate contradiction among population, resources and environment, improve grain production efficiency and increase grain output have always been the hot issues in academic research fields.

Domestic scholars have processing various research of technical efficiency and TFP of grain. Based on Data Envelopment Analysis (DEA), Meng Lingjie calculates the comprehensive technical efficiency, scale efficiency and pure technical efficiency of every wheat belt in China. He supposes increasing investment is the key to increase wheat yield [1]. Wang Mingli analyzes different kind of rice plants in China by applying DEA-Malmquist index. The measurement result claims that the change of technological progress is the most direct factor acting on the change of rice productivity [2]. Using analytical method of DEA-Malmquist index, Yang Chun empirically analyzes the growth of corn TFP in China. The result shows that the average growth rate of TFP of corn in China is 3.7% whose growth trend is U shape [3]. With the aid of Stochastically Frontier Analysis (SFA）, Si Wei analyzes TFP, the technical efficiency, the trend and spatial distribution characteristics of soybean production in China [4]. Applying the analysis of DEA based on the order, Min Rui calculates TFP of grain production in Hubei province. It indicates that the increase of grain production in Hubei province mainly embodies the pattern of technological progress individual drive. The function of technical efficiency improvement is relatively limited [5]. Based on panel data and DEA-Malmquist of input and output of grain in 29 provinces in China, Zhou Minghua calculates and decomposes TFP of grain production. The result indicates that overall TFP of Chinese grain is growing, technological progress and technological efficiency index both achieves positive growth [6].

From the existing literature, the studying scale of TFP of grain in China mainly dominated by countries and provinces, and the research method often adopts DEA-Malmquist index model which is mature enough in contemporary society. The State Council of China officially approved *The Programmer of Poyang Lake Ecological Economic Zone* on December 12th 2009 which means Poyang Lake Ecological Economic Zone has risen to a national strategy. This programmer, focusing on promoting the harmony of ecology and economy, will build Poyang Lake Ecological Economic Zone into an ecological economic demonstration area in China where keeps the ecological civilization and the development of economic society coordinated and the harmony between man and nature. Poyang Lake Ecological Economic Zone consists of 38 counties (cities /area) including Nanchang, Jingdezhen and Yingtan these three cities and some counties (cities/area) in Jiujiang, Xinyu, Fuzhou, Yichun, Shangrao

and Ji'an. Until the end of 2010, the total output of grain in Poyang Lake Ecological Economic Zone is 9,208,000 tons which accounts for 47.1% of the total output of grain in Jiangxi province.

Thus, grain production in this zone plays a firmly important role in guaranteeing the safety of grain in Jiangxi province. Some scholars have been studying the grain of Poyang Lake Ecological Economic Zone since the plan was approved. Zhang Liguo analyzes the condition of agricultural production that influencing grain production in Poyang Lake Ecological Economic Zone through grey correlation model [7]. Liao Huipin etc. apply crop science to analyze the reason causing fluctuation of grain production [8]. Based on correlation analysis, principle component analysis and path analysis, Zhu Zaiyu et al. explore the influencing factors of grain production [9]. However, these works and literature are short of research in relation to the progress of production technology and TFP variation tendency of grain in Poyang Lake Ecological Economic Zone. Due to the limited statistics, higher urbanization level in most municipal districts and low proportion of agricultural production which does not much affect the analysis result, this text chooses panel data of 25 counties (cities) of Poyang Lake Ecological Economic Zone from 2000 to 2010 and adopts non-parametric DEA-Malmquist index model to calculate TFP of grain. This text is aimed at exploring the basic condition of grain production efficiency of this area which offers a theoretical foundation and policy support to enhance grain production efficiency of Poyang Lake Ecological Economic Zone.

2. MODE SETTING AND EXPLANATION OF DATA SOURCES

2.1 Mode setting

Malmquist index was defined by the distance function which is the reciprocal of Farrell technical efficiency. The distance function of indicator variables produced in period *t* as follows:

$$d_0^t(x^t, y^t) = \inf\{\theta : (x^t, y^t / \theta) \in L'\} = (\sup\{\theta : (\quad (1)$$

Among them, x^t and yt are respectively variance matrices of input and output in period t,θ is the index of efficiency towards the output,Lt is called Production Possibility Set in which every subset of maximum output under predetermined cost is also called the frontier of production technology. Malmquist index is calculated by the ratio of the distance function.To define Malmquist index, the distance function in period t+1 is also needed :

$$d_0^{t+1}(x^{t+1}, y^{t+1}) = \inf\{\theta : (x^{t+1}, y^{t+1} / \theta) \in L'\} = (\sup\{\theta : (x \quad (2)$$

Based on period *t* and the output, Malmquist index is defined as:

$$M_0^t(X^t, Y^t, X^{t+1}, Y^{t+1}) = \frac{D_0^t(}{D_0^t} \quad (3)$$

In this formula, $D_0^t(X^t,)$ represents technical efficiency of period *t* which is based on the technology of period *t*, $D_0^t(X^{t+1}, Y$ represents technical efficiency of period *t*+1 which is based on the technology of period *t.* Similarly, in *t*+1th period, Malmquist index based on output can be defined as:

$$M_0^{t+1}(X^t, Y^t, X^{t+1}, Y^{t+1}) = \frac{D_0^{t+1}(}{D_0^{t+} \quad (4)$$

$D_0^{t+1}(X^t,$ in the formula above represents t^{th} technical efficiency based on the technology of period *t*+1. $D_0^{t+}(X^{t+1}, Y^t$ represents technical efficiency of period *t*+1 based on *t*+1th technology. To avoid the influence to the result which is caused by different reference period, Fare etc. calculate TFP index by geometric mean of t^{th} and *t*+1th Malmquist index:

$$M_0^{t,t+1}(X^t, Y^t, X^{t+1}, Y^{t+1}) = \left(\frac{D_0^t(X^{t+1}, Y^{t+1})}{D_0^t(X^t, Y^t)} \times \frac{D_0^{t+1}(X^{t+1}, Y^{t+1}}{D_0^{t+1}(X^t, Y^t)} \right.$$

$$= \frac{D_0^{t+1}(X^{t+1}, Y^{t+1})}{D_0^t(X^t, Y^t)} \times \left(\frac{D_0^t(X^{t+1}, Y^{t+1}}{D_0^{t+1}(X^{t+1}, Y^{t+1}} \right. \quad (5)$$

In this formula, Ech represents technical efficiency, which estimates the catch-up degree of every observable reaching the border of the best production frontier from period *t* to period *t*+1; Tch represents technological progress which estimates the transfer of observables from period *t* to period *t*+1. Decomposition of TFP mentioned above is on account of the hypothesis of Constant Returns to Scale (CRS). To suppose Variable Returns to Scale (VRS), technical efficiency can be further decomposed as pure technical efficiency and scale efficiency. The formula (2-5) can be further decomposed as:

$$M_0^{t,t+1}(X^t, Y^t, X^{t+1}, Y^{t+1}) = \frac{D_0^{t+1}(X^{t+1}, Y^{t+1}, C) / D_0^{t+1}(X^{t+1}, Y^{t+1}, V}{D_0^t(X^t, Y^t, C) / D_0^t(X^t, Y^t, V)}$$

$$\times \left(\frac{D_0^t(X^{t+1}, Y^{t+1})}{D_0^{t+1}(X^{t+1}, Y^{t+1})} \times \frac{D_0^t(X^t, Y^t)}{D_0^{t+1}(X^t, Y^t)} \right)^{1/2}$$

In the formula above, C represents CRS, V represents VRS while PEch is pure technical efficiency and SEch is scale efficiency. When $M_0^{t,t+1}$, TFP from period *t* to period *t*+1 is increasing. When $M_0^{t,t+1}$<, TFP from period *t* to period *t*+1 is decreasing. When $M_0^{t,t+1}$, TFP remains unchanged.

2.2 Explanation of data sources

Based on research productions that have been obtained, along with the reality of Poyang Lake Ecological Economic Zone, this study selects 1 output indicator and 4 input

indicators. The output indicator can be represented by grain total output. The input indicators include labor, land, mechanical power and the amount of fertilizer applied which are prerequisite in grain production. This study chooses the primary industry working population to represent labor input which excludes working population of rural industry and service industry. Also, land input is represented by cultivated land area, mechanical input is represented by the total power of agricultural machinery and the input of fertilizer is represented by the amount of fertilizer applied that calculated by the amount after converted the constituents of nitrogen in nitrogenous fertilizer, the constituents of phosphorus anhydride in phosphate fertilizer and the constituents of potassium oxide in potash fertilizer.

The data of the total grain output, the primary industry working population, cultivated land area, the total power of agricultural machinery and the input of fertilizer this study adopts is from *Nanchang Statistics Yearbook (2000-2011).*

3. EMPIRICAL RESULTS AND ANALYSIS

3.1 System establishment

Adopting DEAP Version 2.1, this study calculates the output and the input data of grain of 25 counties (cities) in Poyang Lake Ecological Economic Zone from 2000 to 2010. Calculating the variation of TFP of grain, decomposing TFP to technical efficiency and technical progress and further decomposing technical efficiency to pure technical efficiency and scale efficiency. Those decomposition results are in Table 1 and Table 2.

Table 1. TFP and its composition changes of grain in poyang lake ecological economic zone (2000—2010)

Year	Technical Efficiency			Technical Progress	TFP
		#Pure Technical Efficiency	#Scale Efficiency		
2000	1.017	0.994	1.023	0.996	1.013
2001	1.019	1.006	1.013	1.000	1.019
2002	0.979	1.003	0.976	1.002	0.981
2003	0.940	0.957	0.982	1.001	0.941
2004	1.052	1.052	1.000	1.221	1.285
2005	1.009	0.993	1.017	1.007	1.016
2006	0.969	0.980	0.989	0.955	0.926
2007	0.968	0.993	0.975	1.019	0.987
2008	0.969	0.951	1.019	0.925	0.897
2009	1.023	1.046	0.978	1.100	1.125
2010	1.045	1.029	1.016	1.012	1.057
2000-2010(mean)	0.999	1.000	0.999	1.019	1.018

Table 2. TFP and its composition changes of grain in 25 counties (cities) (2000—2010)

District	Technical Efficiency			Technical Progress	TFP
		#Pure Technical Efficiency	#Scale Efficiency		
Nanchang county	0.989	0.990	0.999	1.025	1.014
Xinjian county	1.013	1.011	1.002	1.032	1.046
Anyi county	1.000	1.000	1.000	1.015	1.015
Jinxian county	0.995	0.986	1.009	1.051	1.046
Fuliang county	0.986	0.999	0.987	1.026	1.012
Leping city	1.008	1.005	1.003	1.024	1.033
Jiujiang county	1.000	1.008	0.992	1.014	1.013
Wuning county	0.983	1.000	0.983	1.031	1.014
Yongxiu county	0.979	0.972	1.007	0.994	0.973
De'an county	0.985	1.000	0.985	1.021	1.006
Xingzi county	1.004	0.997	1.007	1.025	1.029
District	Technical Efficiency	#Pure Technical Efficiency	#Scale Efficiency	Technical Progress	TFP
Duchang county	1.044	1.043	1.001	1.016	1.061

Hukou county	1.014	1.018	0.996	1.020	1.035
Pengze county	1.013	1.016	0.998	1.022	1.036
Ruichang city	0.933	0.935	0.998	1.012	0.944
Yujiang county	0.986	0.988	0.999	1.005	0.991
Guixi city	0.987	0.987	1.000	1.012	0.999
Xingan county	1.013	1.017	0.997	1.018	1.032
Fengcheng city	1.000	1.000	1.000	1.013	1.013
Zhangshu city	0.996	0.993	1.003	1.032	1.028
Gao'an city	1.002	1.001	1.000	1.029	1.031
Dongxiang county	0.991	0.993	0.998	1.017	1.007
Yugan county	1.007	1.004	1.004	1.021	1.029
Poyang county	1.041	1.041	1.000	1.003	1.044
Wannian county	1.000	1.000	1.000	1.000	1.000
Mean Value	0.999	1.000	0.999	1.019	1.018

3.2 TFP decomposition analysis

3.2.1 TFP changes in time latitude

Table 1 shows that TFP of grain in Poyang Lake Ecological Economic Zone increased from 2000 to 2010 as its average increase rate is 1.8%. TFP increased for 6 years while the other 5 years decreased. In addition, 2004 is the fastest rising year, rose 28.5% over last year. Secondly is 2009, rose 12.5%. 2008 is the biggest falling year of TFP, dropped 10.3% from last year. Secondly is 2006, 7.4%.

Judging from the decomposition of TFP, the increasing of TFP productivity of grain in Poyang Lake Ecological Economic Zone from 2000 to 2010 mainly comes from technical progress whose average increase rate is 1.9%. The fastest rising year of technical progress is 2004, rose 22.1% over last year. Secondly is 2009, rose 10.0%. The biggest decreasing year of technical progress is 2008, dropped 7.5%. Secondly is 2006, dropped 4.5%. Technical efficiency shows a slight decrease as its average decrease rate is 0.1%. The fastest rising year of technical efficiency is 2004, rose 5.2% over last year. Secondly is 2010, rose 4.5%. 2003 is the biggest fall of technical efficiency, dropped 6.0%. Secondly is 2007, dropped 3.2%. Judging from the decomposition condition of technical efficiency, scale efficiency yearly decreased 0.1% while pure technical efficiency held the line during 11 years which shows that the main decreasing reason of technical efficiency is the decrease of scale efficiency.

3.2.2 TFP changes on space latitude

Table 2 shows that TFP of grain in Yongxiu county, Ruichang city, Yujiang county and Guixi city these four counties (cities) are decreasing while TFP of the other 21 counties (cities) are increasing from 2000 to 2010. Among those counties (cities) which TFP is increasing, TFP of grain in Duchang county is the fastest rising one whose average increase rate is 6.1%, followed by Xinjian county and Jinxian county whose average increase rates are both 4.6%. In these counties (cities) which TFP is decreasing, TFP of grain in Ruichang city is the biggest fall as its average decreasing rate is 5.6%, followed by Yongxiu county whose average increasing rate is 2.7%.

Considered from the decomposition of TFP, there is only Yongxiu County in whole 25 counties (cities) whose technology is degenerative as its average decrease rate is 0.6%. Wannian County does not contribute to technical progress during 11 years while the other 23 counties (cities) do. In those counties (cities) whose technology makes progress, Jinxian County is the fastest one as its average increase rate is 5.1%. Xinjian county and Zhangshu city tie for second with its average increase rate is 3.2%. Duchang County is the fastest one in improving technical efficiency, yearly rose 4.4%., followed by Poyang County which average increase rate is 4.1%. The remarkable elevation of technical efficiency of Duchang county and Poyang county derives from the large rise of pure technical efficiency as their average increase rates respectively are 4.3% and 4.1%. On the contrary is Ruichang city whose technical efficiency is the biggest fall as its average decrease rate is 6.7%, followed by Yongxiu County, 2.1%. The technical efficiency of Ruichang city and Yongxiu County shows a greater drop due to the relative drop of pure technical efficiency. Their average decrease rates are 6.5% and 2.8%.

4. SHORT CONCLUSION AND SUGGESTIONS

4.1 Short conclusion

Applying DEA-Malmquist, this study calculates TFP of grain in 25 counties (cities) in Poyang Lake Ecological Economic Zone from 2000 to 2010. Through research analysis, following two conclusions are got:

1. Judging from time latitude, the increase of TFP of grain in Poyang Lake Ecological Economic Zone from 2000 to 2010 is mainly pushed forward by technical progress while technical efficiency shows a slight decrease. The annual increase of TFP of grain is 1.8%, the average increase rate of technical progress is 1.9% and the average decrease rate of technical efficiency is 0.1%. The decrease of technical efficiency ascribes to the fall of scale efficiency as its average decrease rate is 0.1% while there is no change in pure technical efficiency.

2. Seen from space latitude, TFP of grain in Yongxiu county, Ruichang city, Yujiang county and Guixi city these four counties (cities) are decreasing while TFP of the other 21 counties (cities) are increasing. The fastest one to raise TFP of grain is Duchang County while TFP of grain in Ruichang city is the biggest fall. Considered from the decomposition of TFP, there is only Yongxiu County in whole 25 counties (cities)

whose technology is degenerative. Wannian County does not contribute to technical progress and the fastest technical progress is made by Jinxian county. The greater change of pure technical efficiency in Duchang county, Poyang county, Ruichang city and Yongxiu county these 4 counties (cities) is the source of the greater change of technical efficiency.

4.2 Policy suggestions

4.2.1 Enlarge technical research and development and promotion of grain production

In case of positive analysis, the increase of TFP of grain in Poyang Lake Ecological Economic Zone is deficient in technical efficiency as it owns low technology transfer rate and lagging new technology popularization. Therefore, government of all levels starts with enlarging technical research and development and promotion of grain production which is suggested as it helps to improve technological application efficiency and promoting the increase of TFP of grain. Firstly, enlarge investment in new technology research and development. Increase support of key scientific and research projects like fine seeds selection, high-tech irrigation and mechanized farming, gradually enhance the share of agricultural added value that the research spending of agricultural technology and establish long-term mechanism of stable growth of investment to promote technical progress. Secondly, set up scientific research cooperation mechanism with institutions of higher learning and R&D institutions. Combine Jiangxi Agricultural University, Jiangxi Academy of Agricultural Sciences and correlative agriculture-related units to improve scientific research, tackle the key research project and enhance technology transfer rate by applying new technology of grain production. Thirdly, speed up the promotion of new technology. On the basis of economic developing level, farmers' cultural quality and natural condition of grain production, it should adjust measures to local conditions, multi-channel encouraging farmers to adopt proper new technology to tangibly translate new technology of grain production into actual productivity.

4.2.2 Promote scale operation of grain production

In view of empirical analysis, the decrease of scale efficiency of grain production in Poyang Lake Ecological Economic Zone blocks the increase of TFP of grain. Thus, innovation of grain production pattern and the utilization benefit of the cultivated land resources should be enhancing. It is suggested that government of all levels should start with promoting scale operation of grain production to enhance the increase of TFP of grain. Firstly, complete rural land contractual management right and circulate system to regulate land sublease. On the one hand, this measure relieves land excessive fragmentation and improve scale efficiency. On the other hand, it is conducive to concentrate land to processing intensive, mechanical and industrialized management. Secondly, cultivate and develop cooperation organizations of grain production and lead cooperation organizations to develop multiform scale operation. Cooperation organization of grain production is not only in favor of the extension of new technology of grain production and good varieties, but also advantageous to rationally allocating means of production such as agricultural implements, pesticide, fertilizer and so on which is aimed at realizing scale economy of grain production. Thirdly, adjust measure to specific conditions of grain production in various districts to ensure moderate scale of grain production. Enlarge the utilization efficiency of land by cooperating infrastructure construction like farming reorganization and agricultural transformation.

4.2.3 Increasing policy support of grain production

The Party and government have brought out a series of policies supporting agriculture and giving favorable treatment to farmers in recent years. However, the boost of these policies is fleeting so that the long-term utility still has a way to go. Hence, it is suggesting that government at all levels continues to increase financial support for agriculture. Firstly, increase financial support for agriculture. Increase direct subsidies for grain farmers and provide grain subsides timely and sufficient in strict accordance with the requirements. In the meantime, increase financial support of technology extension such as seed subsidies, farm machinery purchase subsidy agricultural general subsidies and so on. The second thing is stabilizing and raising grain purchasing price. Based on the condition of grain production in each county (city), Stabilize and raise the lower-limit policy of purchasing price of key grain varieties to refrain from big frustration that structural surplus causes to enthusiasm of producers. Then the dynamic reward system of grain production should be put into practice. As for those major towns (villages) and counties (cities) of grain production, it is suggest that giving grain productive reward and establishing dynamic reward system of 'can increase or decrease, can in or out' which helps to improve farmers' motivation of growing grains.

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