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Agricultural Credit Institution Efficiency Evaluation Research Based on Data Envelopment Analysis

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Abstract: Agricultural credit plays an important role in rural economic development, so efficiency problem of the agricultural credit has important practical significance. This paper investigates the principle of data envelopment analysis model, super-efficiency model and Malmquist index. We make empirical analysis based on agricultural credit institutions in Jiangsu under super-efficiency model. The results of DEA method show that among Jiangsu agricultural credit institutions, state-owed commercial banks, joint stock commercial banks have the highest efficiency, whereas the efficiency of the rural cooperative financial institutions is relatively lower.

Keywords: Agricultural credit institution efficiency, data envelopment analysis, pure technical efficiency, scale efficiency.

1. INTRODUCTION

As main financial service in China's rural areas, agricultural credit plays an important role in rural economic development [1, 2]. However, the function of agricultural credit is dependent on its own efficiency. Naturally, what is the present situation of the agricultural credit efficiency? What affects and how to improve its level? In order to answer the above questions, the dissertation put agricultural credit institutions as a breakthrough and analyses the relevant problems about agricultural credit efficiency from internal perspective and making comparison by institutions and regions.

Data envelopment (DEA) model is a linear programming technique [3-5], that is one of the most commonly used non-parametric frontier efficiency analysis method, and that is used to evaluate the efficiency of the public sector and non-profit organizations. Sherman and Gold used the DEA technology in the banking sector for the first time, and it is widely used in bank efficiency evaluation. Production boundary computed by DEA model represents an envelope on economics [6-10]. The envelope is boundary formed by the best solution of all possible solutions. Inputs and outputs of all Decision-Making Unit(DMU) is taken into account and the efficiency of individual decision-making unit with respect to the other decision-making unit is calculated [11,12]. All the relative efficiency of the value of 1 (fall in production boundary) is the efficient unit. Relative efficiency value is less than 1 or is the inefficient unit (hardly ever in the production of the boundary). The efficiency value is closer to 1, the higher the efficiency.

The existing research literature explore efficiency of agricultural credit from different perspectives, and different ideas. However, the existing research on the efficiency of agricultural credit also has some disadvantages. Firstly, the efficiency of agricultural credit has not been given a clear definition. Some definition did not seize the essential attribute of the input-output of efficiency and the given definition has yet to have a more consistent standard. Although some studies give the definition of multi-level and integrated concept, there is no depth to quantify efficiency of agricultural credit and lack of comparative analysis of the efficiency of agricultural credit in time and space. Secondly, a lot of research rarely distinct for rural finance and agricultural credit issues strictly. Rural financial efficiency is made equivalent to the efficiency of rural credit. Thirdly, the existing research literature having the proposed measures for improving the efficiency of agricultural credit were mostly dispersed or single and just proposed policy recommendations to improve the efficiency of agricultural credit from one angle which did not form a complete and clear solution to the problem.

In the next section, we investigate the principle of data envelopment analysis model. In Section 3 we study super-efficiency model and Malmquist index [13-16]. In Section 4, we make empirical analysis based on agricultural credit institutions in Jiangsu under super-efficiency model. In Section 5 we conclude the paper and give some remarks.

2. DEA MODEL INTRODUCTION

Constant returns to scale of DEA determines effective production frontier through the analysis of data of input and output of decision making units. It determines DEA effectiveness of each DMU according to each DMU and distance situation of effective production frontier which is proposed by Charness and Cooper. Supposing there are five commercial banks A, B, C, D, and E which is shown in Fig. (**1**). Each commercial bank has two kinds of input and one kind of output. A, B, C, and D is effective commercial banks which constitutes production frontier, and E is ineffective commercial banks. $E^{'}$ and $C^{'}$ is intersection of line segment OE and line segment OC in the production frontier ABCD. Efficiency value of commercial bank E is $TEE = OE^{'} / OE < 1$. Efficiency value of commercial bank C

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is $TEC = OC^{'} / OC = 1$. We can see that efficiency value of ineffective commercial bank is less than 1 and efficiency value of effective commercial bank is equal to 1.

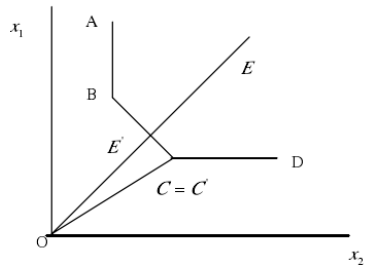

Fig. (1). The efficiency of commercial banks.

The commercial banks constitutes samples and each commercial bank is different decision making units. Input data and output data of each decision making units is represented by x_{ij} and y_{rj}. x_{ij} is input of the j-th decision making units to the i-th input and $x_{ij} > 0$. y_{rj} is output of DMU_j to the r-th output and $y_{rj} > 0$. v_i is a kind of weight to the i-th input. u_r is a kind of weight to the r-th output. $i = 1,2,\ldots,m$, $j = 1,2,\ldots,n$, $r = 1,2,\ldots,s$. In order to convenience, it is named as follows. For DMU_j, its efficiency evaluation index is calculated by formula 1. We can choose suitable weight coefficient v, u to make $h_j \le 1$.

$$X_j = (x_{1j}, x_{2j}, \ldots, x_{mj})^{\tau},\ j = 1,2,\ldots,n.$$

$$Y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})^{\tau},\ j = 1,2,\ldots,n.$$

$$v = (v_1, v_2, \ldots, v_m)^{\tau},\ u = (u_1, u_2, \ldots, u_s)^{\tau}.$$

$$h_j = \frac{u^{\tau} Y_j}{v^{\tau} X_j},\ j = 1,2,\quad ,n \tag{1}$$

We take efficiency evaluation index $h_{j0} = \frac{u^{\tau} Y_{j0}}{v^{\tau} X_{j0}}$ of DMU_{j0} as target and take efficiency evaluation index $h_j = \frac{u^{\tau} Y_j}{v^{\tau} X_j}$ of all decision making units as constraints to constitute the following fractional programming problem. Because formula 2 is difficult to calculate, it is transformed to formula 3. Supposing θ is the technology efficiency value of the bank and $0 \le \theta \le 1$. The dual planning of linear programming is shown in formula 4. In the CRS model, scale inefficiency could affect the whole efficiency. In order to solve this problem, VRS model was proposed. Technology efficiency is decomposed to pure technical efficiency and scale efficiency which is shown in formula 5.

$$\begin{cases} \max h_{j0} = \dfrac{u^{\tau} Y_{j0}}{v^{\tau} X_{j0}} \\ h_j = \dfrac{u^{\tau} Y_j}{v^{\tau} X_j} \le 1,\ j = 1,2,\quad ,n \\ u \ge 0,\ v \ge 0 \end{cases} \tag{2}$$

$$\begin{cases} \max u^{\tau} Y_{j0} \\ w^{\tau} X_j - u^{\tau} Y_j \ge 0,\ j = 1,2,\ldots n \\ w^{\tau} X_{j0} = 1, w \ge 0, u \ge 0 \end{cases} \tag{3}$$

$$\begin{cases} \min \theta \\ \sum_{j=1}^{n} X_j \lambda_j \le \theta X_{j0} \\ \sum_{j=1}^{n} Y_j \lambda_j \ge Y_{j0} \\ \lambda_j \ge 0,\ j = 1,2,\quad ,n \end{cases} \tag{4}$$

$$\begin{cases} \min \delta \\ \sum_{j=1}^{n} X_j \lambda_j \le \delta X_{j0} \\ \sum_{j=1}^{n} Y_j \lambda_j \ge Y_{j0} \\ \sum_{j=1}^{n} \lambda_j = 1 \\ \lambda_j \ge 0,\ j = 1,2,\quad ,n \end{cases} \tag{5}$$

3. SUPER-EFFİCİENCY MODEL AND MALMQUİST İNDEX

Super-efficiency model is shown in Fig. (**2**). Take commercial bank C for example. C is located in production frontier and CRS model efficiency value of commercial bank C is 1. According to super-efficiency, point C should be excluded from the reference collection of the commercial banks when calculating the efficiency value of commercial bank C. So production frontier ABCD is transformed to ABD. Then efficiency value of C is $TEC = OC^{'} / OC > 1$. For inefficient commercial bank E in CRS model, its efficiency value is consistent with CCR model $TEE = OE^{'} / OE < 1$.

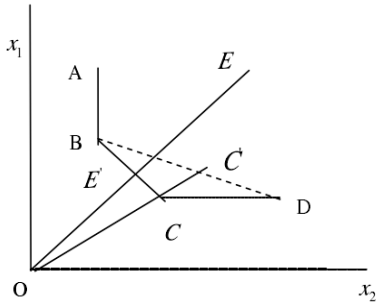

Fig. (2). The super-efficiency of commercial banks.

Malmquist index represents the whole efficiency change degree of banks from period of t to period of t+1. If $M > 1$, it represents that productivity rises. Otherwise, it represents that productivity falls. Malmquist index can be decomposed of relative technology change and technology progress change. Efficiency change EC is relative efficiency change which represents technology efficiency change degree from period of t to period of t+1. Technical change TC represents

production technology change from period of t to period of t+1. If $TC > 1$, it represents production technology make progress. Otherwise it represents production technology has the trend of decay. Malmquist index can reflect intertemporal change degree of banks' overall productivity.

4. EMPIRICAL RESEARCH

Commercial banks as the special enterprise operating currencies and there are three definitions of the input-output method usually. Production approach takes banks as producers of financial products. The number of deposit accounts and loan items are taken as output, and capital and labor are input items. Intermediate approach takes banks as intermediaries which transform savings into investment with the amount of deposits and loans as its output, labor and capital as input. Asset approach takes banks as financial intermediaries, but only project of its assets in the balance sheet was as outputs. Of these three methods, even adopting the same method, because of the different sources of data and other reasons, input-output selection of projects is not exactly the same. Considering the above method, the input variables selected in the evaluation of the internal efficiency of the agricultural credit institutions include the number of employees, and net capital (total working capital). Output variables include total profit, and the loan balance.

Firstly, in accordance with the classification of the type of institution this paper calculates the efficiency of the sample agricultural credit institutions. Agricultural credit institutions is divided into six types, the agricultural development bank of China, agricultural bank, rural cooperative financial institutions (including rural credit cooperatives and rural cooperative banks), the postal savings banks, rural banks and other agricultural credit institutions (including state-owned commercial banks, joint-stock commercial banks and city commercial banks, etc.). The regional postal savings banks and rural banks began to be set up from 2008. Before 2008 we only analyze the relative efficiency of four types of agricultural credit institutions. In order to more clearly reflect the rankings of the efficiency value and the efficiency of various types of agricultural credit institutions, this article uses the DEA super-efficiency model to calculate the efficiency of sample agricultural credit institutions. The efficiency of agricultural credit institutions in Jiangsu under super-efficiency model is shown in Table **1**.

In Table **1** and Table **2**, ADB represents agricultural development bank, AB represents agricultural bank, RCFI represents rural cooperative financial institutions, OACI represents other agricultural credit institutions, PSB represents postal savings bank, RB represents rural bank, be represents business efficiency, se represents scale efficiency, and si represents scale interval. The meaning of Inv is invariant, the meaning of Dec is decreasing and the meaning of Inc is increasing.

From Table **1** we can get the following conclusions. In the internal efficiency of the various types of agricultural credit institutions, other agricultural credit institutions has the highest efficiency. In each year from 2000 to 2009, its efficiency is the highest in the various types of agricultural credit institutions, and the average efficiency reaches 1.044. This shows that from the view of the county, compared to the efficiency of state-owned commercial banks (excluding agricultural bank) as well as the efficiency of the joint-stock commercial banks, other agricultural credit institutions has the highest efficiency. Average efficiency value in the second from 2000 to 2009 is the agricultural development bank and its 10-year average efficiency is 0.80. This is mainly because as a policy bank, the agricultural development bank does not has the business of absorbing deposit, so capital investment and the number of workers is relatively small. Overall, efficiency of rural cooperative financial institutions (including rural credit cooperatives and rural cooperative banks) are relatively low, the 10-year average efficiency value is only 0.439. Our country started rural credit cooperatives reform from 2003. From the view of rural credi

Table 1. The efficiency of agricultural credit institutions in Jiangsu under super-efficiency model.

	ADB	AB	RCFI	OACI	PSB	RB
2000	0.788	0.871	0.428	0.923	-	-
2001	0.693	0.973	0.568	1.081	-	-
2002	0.581	0.628	0.451	0.910	-	-
2003	0.866	0.496	0.453	0.953	-	-
2004	0.908	0.515	0.533	1.025	-	-
2005	0.624	0.583	0.436	0.937	-	-
2006	0.760	0.546	0.427	1.015	-	-
2007	0.883	0.675	0.438	1.334	-	-
2008	1.064	0.713	0.310	1.221	0.07	0.17
2009	0.837	0.761	0.353	1.044	0.05	0.11
mean value	0.800	0.676	0.439	1.044	0.06	0.14

Table 2. Pure technical efficiency, scale efficiency and scale interval of agricultural credit institutions in Jiangsu.

		ADB	AB	RCFI	OACI	PSB	RB
2000	be	1.00	0.09	0.463	1.00	-	-
	se	1.00	0.93	0.987	1.00	-	-
	si	Inv	Inc	Inc	Inv	-	-
2001	be	1.00	1.00	0.505	1.00	-	-
	se	1.00	0.78	0.956	1.00	-	-
	si	Inv	Dec	Dec	Inv	-	-
2002	be	1.00	0.59	0.471	1.00	-	-
	se	1.00	1	0.559	1.00	-	-
	si	Inv	Inv	Dec	Inv	-	-
2003	be	1.00	0.83	0.457	1.00	-	-
	se	1.00	0.99	0.670	1.00	-	-
	si	Inv	Inc	Dec	Inv	-	-
2004	be	1.00	0.68	0.444	1.00	-	-
	se	1.00	0.999	0.576	1.00	-	-
	si	Inv	Inv	Dec	Inv	-	-
2005	be	1.00	0.64	0.514	1.00	-	-
	se	1.00	0.99	0.444	1.00	-	-
	si	Inv	Inc	Dec	Inv	-	-
2006	be	1.00	0.75	0.644	1.00	-	-
	se	1.00	0.93	0.657	1.00	-	-
	si	Inv	Dec	Dec	Inv	-	-
2007	be	1.00	0.95	0.552	1.00	-	-
	se	1.00	0.84	0.629	1.00	-	-
	si	Inv	Dec	Dec	Inv	-	-
2008	be	1.00	0.80	0.580	1.00	0.06	1.00
	se	1.00	0.93	0.569	1.00	0.82	0.11
	si	Inv	Dec	Dec	Inv	Inc	Inc
2009	be	1.00	0.74	0.430	1.00	0.08	1.00
	se	1.00	0.99	0.687	1.00	0.85	0.17
	si	Inv	Inc	Dec	Inv	Inc	Inc

cooperatives, the reform has achieved great success, and its efficiency has been improved significantly. However, compared with other agricultural credit institutions its efficiency is still relatively low. In addition, the postal savings bank and rural bank was established in 2008. The operation of the agency is not very mature, and it is still in the initial input stage, so the relatively low efficiency. From sample agricultural credit institutions of Jiangsu province in 2000, standard deviation of internal efficiency value of agricultural credit institutions was increasing which increased from 0.223 in 2000 to 0.482 in 2008. While it decreased in 2009, it still amounted to 0.411 which is shown in Fig. (**3**). This shows that on the whole, the development gap of different agricultural credit institutions is growing. On the one hand, the efficiency of commercial banks including agricultural bank was obviously improved after a series of reforms. But the development of other institutions represented by the rural credit cooperatives is slow.

Pure technical efficiency, scale efficiency and scale interval of agricultural credit institutions in Jiangsu are shown in Table **2**. Firstly, business efficiency and scale efficiency of the agricultural development bank and other agricultural credit institutions is 1, which shows that agricultural development bank and other agricultural credit institutions have moderate production and management. Secondly, except 2001 and 2007, scale efficiency of agricultural bank is higher than business efficiency, which shows that agricultural bank

scale is effective, but in some year large asset size resulted in invalid scale. In 2009 the scale efficiency of agricultural bank reached 0.994, and it is in the stage of increasing returns, which shows that the joint-stock reform of the agricultural bank started to gradually merge and integrate part of the branches, optimize network configuration, and improve its efficiency. For rural cooperative financial institutions, in addition to 2000 in the stage of increasing scale returns, the other years are in decreasing returns, indicating that the rural cooperative financial institutions have not completely came out of the old extensive management, and the level of concentration needs to be improved. Rural banks and postal savings banks are in the stage of increasing returns, the newly established rural financial institutions should scale up. Especially scale efficiency of rural bank is low, which shows that the village bank also has the very big development space in number.

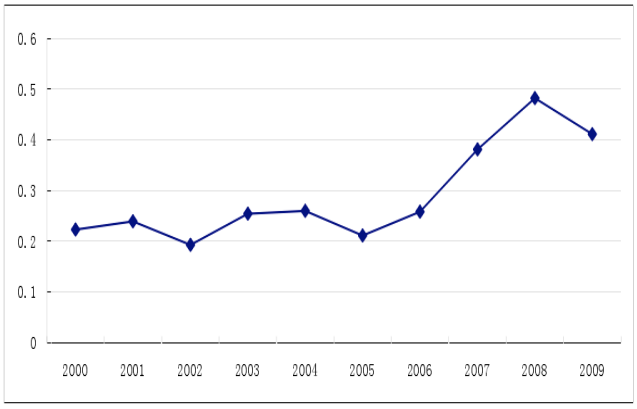

Fig. (3). The standard deviation change of internal efficiency of Jiangsu Province sample agricultural credit institutions.

CONCLUSION

This paper investigates principle of DEA method and the efficiency of agricultural credit institutions in Jiangsu under super-efficiency model is studied. The result shows that agricultural development bank and other agricultural credit institutions have moderate production and management. The joint-stock reform of the agricultural bank started to gradually merge and integrate part of the branches, optimize network configuration, and improve its efficiency. Rural cooperative financial institutions have not completely come out of the old extensive management. Rural banks and postal savings banks are in the stage of increasing returns.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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