行政院國家科學委員會專題研究計畫 成果報告

台灣農會信用部效率與生產力之分析
研究成果報告(精簡版)

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中 華 民 國 100 年 09 月 22 日

目錄

一、報告內容

本計劃名稱為「台灣農會信用部效率與生產力之分析」，原本為申請兩年期的計畫，但最後只通過一年，因此目前只執行有關「效率分析」的部分。以下為利用 Two-stage Production System Method 所分析的內容：

1. Introduction

Agricultural development is considered as the foundation of industrial development during the economic evolution of Taiwan. In spite that the percentage of agricultural production to the GDP have decreased dramatically after the growth of economy, agriculture still remain as an important industry because of politics, food safety, and ecological environment preservation, etc. reasons in Taiwan as in many other industrial countries. In order to sustain agricultural production and improve well-being in rural communities continuously, rural finance would be still one of the important means that facilitated agricultural development.

Therefore, the major purpose of this study is to examine the effects of this agricultural financial reform on the performance of the FCUs in Taiwan. In particular, we will focus on the technical efficiency evolutions of FCUs over the period of 2001-2009 by using a two-stage Data Envelopment Analysis (DEA) method. In banking literature, there is a long-standing disagreement over whether deposits should be counted as inputs or outputs. We follow the idea of Fukuyama and Weber (2010) to treat the deposits of FCUs as an intermediate output to overcome this difficulty. That is, in the first stage, FCUs combine labor, fixed capital, and operating expenses to raise deposits, which serve as an intermediate output. In the second stage, the deposits raised from the first stage are then used as inputs in its second stage production to produce loans and other non-loan outputs in which some loans might become undesirable non-performing. The model is developed using Kao and Hwang's (2011) relational model with an extension to include undesirable outputs to estimate both the pure technical efficiencies and scale efficiencies for the system as well as the component process of FCUs. By using this network specification, the specific sources of inefficiency embedded in interactions between operating activities of deposits and loans can be addressed. Then, Simar and Wilson's (2007) bootstrap method is applied to investigate factors (either exogenous or endogenous) that might explain the performance evolutions each production process of the FCUs in Taiwan.

2. Methodology

In this study, the unified two-stage relational model of Kao and Hwang (2011) is revised to evaluate the process technical and scale efficiencies of FCUs to help managers detect their managerial problems. It is noted that non-performing loans or bad loans are a by-product of the loan production process and do not occur after a loan has been made (Fukuyama and Weber, 2008). Because non-performing loan are undesirable and their reduction is costly, in monitoring the efficiency performance of FCUs, it is required to take this undesirable factor into account, otherwise, FCUs that scrimp on credit evaluations or generate excessively risky loans might be mistakenly regarded as being efficient or more productive, while FCUs that expend more resources to ensure that their loans are of higher quality might be considered to be inefficient or less productive (Chen, et al., 2007). Therefore, following Chang (1999) and Park and Weber (2006), non-performing loans are treated as a joint but undesirable output of the FCUs' productions. Fig. 1 shows the two-stage structure of the FCUs' intermediation processes.

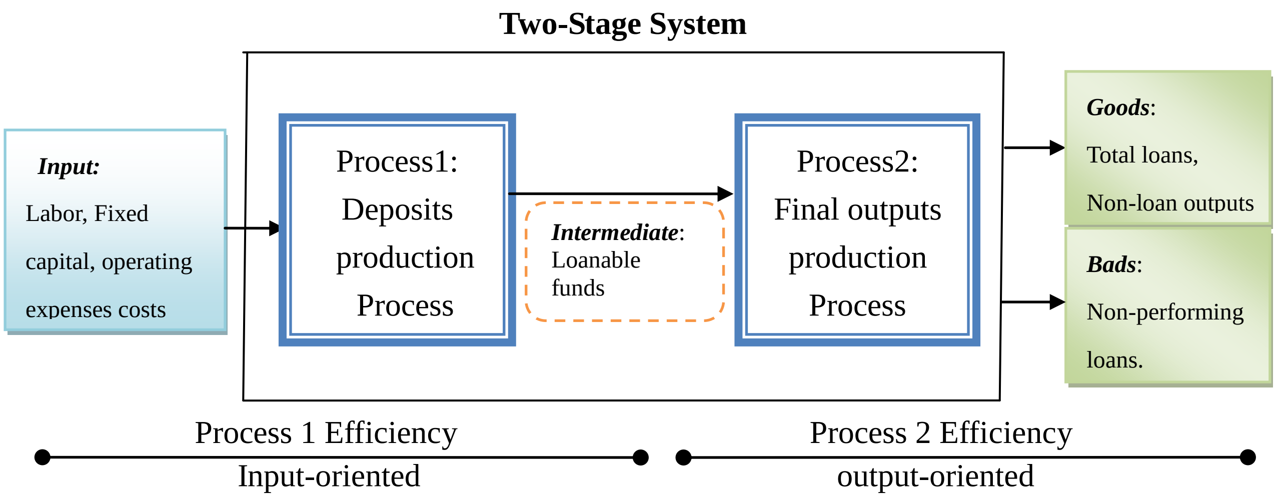

Fig. 1. Two-stage System of FCUs

2.1 The constant return to scale (CRS) efficiency measures

Suppose there are $k=1,\cdots,K$ decision making units (DMUs, FCUs in this study), and each engages in employing inputs X_{nk}, $n=1,\cdots,N$, to produce intermediate outputs Z_{pk}, $p=1,\cdots,P$, in process 1, which in turn are used by process 2 to jointly produce desirable outputs Y_{mk}, $m=1,\cdots,M$, and undesirable outputs B_{jk}, $j=1,\cdots,J$. Following Kao and Hwang (2011) and Jahanshahloo et al. (2004), the CCR (Charnes et al., 1978) two-stage relational model including bads for estimating the overall efficiency (technical efficiency) of DMU k', $k'=1,\cdots,K$ under CRS technology can be expressed as follows:

$$E_{k'}^{s} = \max \left(\sum_{m=1}^{M} u_m Y_{mk'} - \sum_{j=1}^{J} \rho_j B_{jk'}\right) \Big/ \sum_{n=1}^{N} v_n X_{nk'} \qquad (1)$$

$$\begin{aligned}
\text{s.t} \quad & \left(\sum_{m=1}^{M} u_m Y_{mk} - \sum_{j=1}^{J} \rho_j B_{jk}\right) \Big/ \sum_{n=1}^{N} v_n X_{nk} \le 1 && k=1,\cdots,K. \\
& \sum_{p=1}^{P} w_p Z_{pk} \Big/ \sum_{n=1}^{N} v_n X_{nk} \le 1 && k=1,\cdots,K. \\
& \left(\sum_{m=1}^{M} u_m Y_{mk} - \sum_{j=1}^{J} \rho_j B_{jk}\right) \Big/ \sum_{p=1}^{P} w_p Z_{pk} \le 1 && k=1,\cdots,K. \\
& u_m, v_n, w_p \ge \varepsilon,\ \rho_j \ \ free,\ m=1,\cdots,M,\ n=1,\cdots,N,\ p=1,\cdots,P,\ j=1,\cdots,J
\end{aligned}$$

where v_n, w_p, u_m, and ρ_j are the multipliers (shadow prices) associated with the inputs, intermediate products, good outputs and bad outputs and ε is a small non-Archimedean number. It is noted that the weak disposability of bad outputs is implemented by treating the multipliers of undesirable outputs as free variables.

As the optimal solution obtained, due to model (1)'s network structure, not only the system efficiency, $E_{k'}^{s}$, but also the process efficiencies can be calculated as :

$$E_{k'}^{1} = \sum_{p=1}^{P} w_p Z_{pk'} \Big/ \sum_{n=1}^{N} v_n X_{nk'} \qquad (2)$$

$$E_{k'}^{2} = \left(\sum_{m=1}^{M} u_m Y_{mk'} - \sum_{j=1}^{J} \rho_j B_{jk'}\right) \Big/ \sum_{p=1}^{P} w_p Z_{pk'}$$

Apparently, the system CRS technical efficiency (TE) is the product of the two process TEs, i.e., $E_{k'}^{s} = E_{k'}^{1} \times E_{k'}^{2}$. However, as mentioned by Kao and Hwang (2008, 2011), there may have multiple solutions for the two process efficiencies of the relational system model and cause the efficiencies of the two processes incomparable. In order to overcome this difficulty, Kao and Hwang (2008) suggested using the maximum value of $E_{k'}^{1}$ or $E_{k'}^{2}$ for comparison, depending on which process is considered more important. Here we present the method to maximize $E_{k'}^{1}$. That is:

$$E_{k'}^{1} = \max \sum_{p=1}^{P} w_p Z_{pk'} \Big/ \sum_{n=1}^{N} v_n X_{nk'}$$

$$\text{s.t} \quad \left(\sum_{m=1}^{M} u_m Y_{mk'} - \sum_{j=1}^{J} \rho_j B_{jk'}\right) \Big/ \sum_{n=1}^{N} v_n X_{nk'} = E_{k'}^{s} \qquad (3)$$

$$\sum_{p=1}^{P} w_p Z_{pk} \Big/ \sum_{n=1}^{N} v_n X_{nk} \le 1 \qquad k = 1, \cdots, K.$$

$$\left(\sum_{m=1}^{M} u_m Y_{mk} - \sum_{j=1}^{J} \rho_j B_{jk}\right) \Big/ \sum_{p=1}^{P} w_p Z_{pk} \le 1 \qquad k = 1, \cdots, K.$$

$$u_m, v_n, w_p \ge \varepsilon, \ \rho_j \ \ free, \ \ m = 1, \cdots, M, \ n = 1, \cdots, N, \ p = 1, \cdots, P, \ \ j = 1, \cdots, J$$

where $E_{k'}^{s}$ the system efficiency obtained from Model (1) so that model (3) means the TE ratio of Process 1 is maximized under the constraints that the optimal CRS system efficiency is maintained. After the maximum TE for Process 1 obtained, due to $E_{k'}^{s} = E_{k'}^{1} \times E_{k'}^{2}$, we can easily calculated the TE for Process 2 by $E_{k'}^{2} = E_{k'}^{s} / E_{k'}^{1}$.

3.2 The variable return to scale (VRS) efficiency measures

It is well known that TE can be decomposed into two components, one due to pure technical inefficiency (ie. VRS efficiency, hereafter PTE) and one due to scale inefficiency (Coelli et al., 1998). Because the two CRS process efficiencies are calculated in the order of maximizing process 1's efficiencies first and then process 2's efficiencies as described above, following Kao and Hwang (2011), we can have the following two PTE programming problems to calculate the VRS process efficiencies, $T_{k'}^{1}$ and $T_{k'}^{2}$ by maximizing the virtual input-output ratio of the two processes, respectively:

$$T_{k'}^{1} = \max \left(\sum_{p=1}^{P} w_{p}^{'} Z_{pk'} - \delta_{1}\right) \Big/ \sum_{n=1}^{N} v_{n} X_{nk'}$$

$$\text{s.t} \quad \left(\sum_{m=1}^{M} u_{m} Y_{mk'} - \sum_{j=1}^{J} \rho_{j} B_{jk'}\right) \Big/ \sum_{n=1}^{N} v_{n} X_{nk'} = E_{k'}^{s} \qquad (4)$$

$$\sum_{p=1}^{P} w_{p} Z_{pk} \Big/ \sum_{n=1}^{N} v_{n} X_{nk} \le 1 \qquad k = 1, \cdots, K.$$

$$\left(\sum_{m=1}^{M} u_{m} Y_{mk} - \sum_{j=1}^{J} \rho_{j} B_{jk}\right) \Big/ \sum_{p=1}^{P} w_{p} Z_{pk} \le 1 \qquad k = 1, \cdots, K.$$

$$\left(\sum_{p=1}^{P} w_{p}^{'} Z_{pk} - \delta_{1}\right) \Big/ \sum_{n=1}^{N} v_{n} X_{nk} \le 1 \qquad k = 1, \cdots, K.$$

$$u_{m}, v_{n}, w_{p}, w_{p}^{'} \ge \varepsilon, \ \ \rho_{j}, \delta_{1} \ \ free \quad , \quad m = 1, \cdots, M, \quad n = 1, \cdots, N, \quad p = 1, \cdots, P,$$

$$j = 1, \cdots, J$$

$$T_{k'}^{2} = \max \left(\sum_{m=1}^{M} u_{m} Y_{mk'} - \sum_{j=1}^{J} \rho_{j} B_{jk'}\right) \Big/ \left(\sum_{p=1}^{P} w_{p}^{'} Z_{pk'} + \delta_{2}\right)$$

$$\text{s.t} \quad \left(\sum_{m=1}^{M} u_{m} Y_{mk'} - \sum_{j=1}^{J} \rho_{j} B_{jk'}\right) \Big/ \sum_{n=1}^{N} v_{n} X_{nk'} = E_{k'}^{s}$$

$$\sum_{p=1}^{P} w_p Z_{pk'} \Big/ \sum_{n=1}^{N} v_n X_{nk'} = E_{k'}^{1} \tag{5}$$

$$\sum_{p=1}^{P} w_p Z_{pk} \Big/ \sum_{n=1}^{N} v_n X_{nk} \le 1 \qquad k = 1, \cdots, K.$$

$$(\sum_{m=1}^{M} u_m Y_{mk} - \sum_{j=1}^{J} \rho_j B_{jk}) \Big/ \sum_{p=1}^{P} w_p Z_{pk} \le 1 \qquad k = 1, \cdots, K.$$

$$(\sum_{m=1}^{M} u_m Y_{mk} - \sum_{j=1}^{J} \rho_j B_{jk}) \Big/ (\sum_{p=1}^{P} w_p^{'} Z_{pk} + \delta_2) \le 1 \qquad k = 1, \cdots, K.$$

$$u_m, v_n, w_p, w_p^{'} \ge \varepsilon, \ \rho_j, \delta_2 \ free \ , \quad m = 1, \cdots, M, \quad n = 1, \cdots, N, \quad p = 1, \cdots, P,$$

$$j = 1, \cdots, J$$

$$u_m, v_n, w_p \ge \varepsilon, \ \rho_j \ \ free, \ m = 1, \cdots, M, \ n = 1, \cdots, N, \ p = 1, \cdots, P, \quad j = 1, \cdots, J$$

Upon the conducting of both the CRS and VRS programming models, scale efficiency can be obtained by calculating the ratio of TE to PTE. That is, the system's SE can be calculated as $S_{k'}^{s} = E_{k'}^{s} / T_{k'}^{s}$ and the two processes' SEs as $S_{k'}^{1} = E_{k'}^{1} / T_{k'}^{1}$ and $S_{k'}^{2} = E_{k'}^{2} / T_{k'}^{2}$ respectively. Therefore, we can have the following overall system TE decomposition:

$$E_{k'}^{s} = E_{k'}^{1} \times E_{k'}^{2} = (T_{k'}^{1} \times S_{k'}^{1}) \times (T_{k'}^{2} \times S_{k'}^{2})$$

$$E_{k'}^{s} = T_{k'}^{s} \times S_{k'}^{s} = (T_{k'}^{1} \times T_{k'}^{2}) \times (S_{k'}^{1} \times S_{k'}^{2}) \tag{6}$$

3. Data and Variable Specification

Specifically, there are three inputs in the process 1, namely labor (*X1*), other operating expense (*X2*), and fixed assets (*X3*), used to produce the intermediate output, loanable funds (*Z*). The intermediate is then become the input in the process 2 to produce three outputs which include two desirable outputs: total loans (*Y1*), and non-loan output (*Y2*), and one undesirable output: non-performing loans (*B*). The sample used for this analysis consists of 232 FCUs out of a total of 275 FCUs in

Taiwan for nine consecutive years, 2001-2009, the other 43 FCUs being omitted due to being taken over, or because of incomplete of data. These data are obtained from the *Farmers' Association Yearbook* published by the Taiwan Provincial Farmers' Association.

As for the efficiency influential factors, three categories of explanatory variables are specified. The first includes three risk and asset quality variables to characterize the three different types of risk, namely liquidity, credit and capital risk. (i) ***Liq_ratio:*** liquidity ratio (***Liq_ratio***) defined in terms of the ratio of current assets to current liability is used to measure of a FCU's ability to meet its obligations to depositors. (ii) ***Cover_ratio:*** is the loan loss coverage ratio. (iii) ***CAR:*** Capital adequacy ratio measured by equity over total assets is included to capture the impact of capital risk regulatory conditions.

The second is the FCU-specific variables include: (i) ***Inter_ratio***: is the intermediation ratio refers to the ratio of total loans to total deposits. (ii) ***Education:*** The proportion of employees with a college degree and above is employed to characterize the employees' quality. (iii) ***Membership:*** The members of FCUs consist of regular members (or voting members), and associate members (or non-voting members). (iv) ***#branch*:** This is the number of branches a FCU operates.

The third is the additional variables. (i) ***#bank*:** is the Number of local banks used as a proxy to represent the degree of market competition faced by FCUs. (ii) ***Gr_rate*:** The GDP growth rate is included to capture the effects of the movements in the business cycle (iii) ***Time*:** The time trend variable is used to examine efficiency change over time.

4. Empirical Results

4.1 Behavior of efficiency measures over time

It is shown that the average system technical efficiency score over 2001~2009 is only 0.432, with a range from 0.095 to 1.000, and suggests a pretty great room for FCUs to improve their efficiency by reducing inputs and bad outputs and increasing good outputs by 56.8% on average. The decomposition indicates that the average PTE is 0.503 and is lower than that of SE. This means that the efforts to improve efficiency by saving cost using, expanding good outputs and abating bad outputs are more important than by altering the production scale for the sample FCUs. Besides, It also can be found that the technical inefficiencies are mainly from the deposits production process, with an average of 0.593, and less from final outputs production process, with an average of 0.733.

In order to examine whether the agricultural financial reform strengthens the efficiencies of FCUs, the sample years are divided into three periods, namely, pre-form (2001-2003), reform (2004-2005), and post-reform (2006-2009) to compare the efficiency of pre-form and post-reform periods. The statistic test results (p-values) confirm that the system and process 1 efficiencies are all significantly higher during the post-reform periods than those during the pre-reform periods at least at 10% significant level while they are indifferent from each other between these two periods for the process 2. That is, agricultural financial reform has improved the efficiencies of FCUs for both production processes at during 2006-2007.

4.2 Factors that influence FCU performance

Table 5 reports the estimate of the selective efficiency explanatory variables for the system TE as well as PTE. It is found that for the three risk and asset quality variables, only the coefficients of *Cover_ratio* are significantly positive. For the

FCU-specific variables, *Inter_ratio* is not an influential variable. Consistent with the prior expectations, both the TE and PTE is significantly positively associated with *Education* and significantly negatively associated with *Membership*. The negative sign of *#branch* indicates that a branch network is costly for FCUs in spite that the impact for TE is not significant. This result is similar to those of Fukuyama and Matousek (2011). At last, for the additional variables, *# bank* also only show significantly impact on PTE only. The positive estimate tells that the positive effect of competition outweighs the negative one for the FCUs. The coefficients of *Gr_rate and Time* are both significantly positive indicating that the efficiencies of FCUs are positively associated with the economic cycle and improved over time after controlling the impacts of other variables.

5. Conclusions

This paper includes undesirable outputs into the Kao and Hwang's (2011) two-stage relational model to investigate the impact of agricultural financial reform on the technical and scale efficiencies of Taiwan's FCUs by using a panel data over the period 2001-2009. Since the system model considers the linkage of different processes explicitly, it enables us decompose the efficiency scores for individual processes/activities so that sources of inefficiency can be identified.

The results show that the average system technical efficiency score over sample period is only 0.432 suggesting a pretty great room for FCUs to improve their efficiency. The decomposition indicates that the inefficiency is mainly from pure technical inefficiency rather than scale inefficiency. The process efficiency results signify that the efforts to improve inputs utilitiztion efficiency in the process 1 are more important than to improve loan creation and problem loan control efficiencies in the process 2. It is also found that the FCUs positively reacted to financial reform process. It is evident that although there is a decline in performances during the period reform program introduced, FCUs' efficiency improved after it.

The regression results show that the loan loss coverage ratio, education degree of employees, competition and economic growth are positive factors of FCUs' performances while ratios of regular members and number of branches are negative factors. Therefore, it is helpful for FCUs to increase their ability to absorb potential losses from nonperforming loans and upgrade employees' education degree. For the FCUs with greater number of branches, it is important for them to overcome the difficulty in coordination, administration and management among braches.

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三、計畫成果自評

本計畫研究內容適合於投稿至學術期刊，目前已先將研究成果投稿至 2011 年農業經濟學術研討會，並預計投稿至 Agricultural economics 期刊。

國科會補助計畫衍生研發成果推廣資料表

日期:2011/09/20

國科會補助計畫	計畫名稱: 台灣農會信用部效率與生產力之分析
	計畫主持人: 陳柏琪
	計畫編號: 99-2410-H-216-001- 學門領域: 農業與自然資源經濟學

無研發成果推廣資料

99 年度專題研究計畫研究成果彙整表

計畫主持人：陳柏琪	計畫編號：99-2410-H-216-001-
計畫名稱：台灣農會信用部效率與生產力之分析	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	1	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	1	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	1	0	100%		
國外	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估 ■達成目標 □未達成目標（請說明，以 100 字為限） □實驗失敗 □因故實驗中斷 □其他原因 說明：
2. 研究成果在學術期刊發表或申請專利等情形： 論文：□已發表 ■未發表之文稿 □撰寫中 □無 專利：□已獲得 □申請中 ■無 技轉：□已技轉 □洽談中 ■無 其他：（以 100 字為限）
3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限） 本計畫研究內容適合於投稿至學術期刊，目前已先將研究成果投稿至 2011 年農業經濟學術研討會，並預計投稿至 Agricultural economics 期刊。 另一方面，根據本研究所建立的研究模型，可以提供其他也有興趣以兩階段 DEA 系統模型作為研究方法之研究參考。實證結果結果部分，則可提供信用部與政府調整經營方向與制定政策參考。