

Lecture Notes in Electrical Engineering 551

Jason C. Hung
Neil Y. Yen
Jia-Wei Chang *Editors*

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Editors

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Efficiency of Financial Holding and Non-financial Holding Bank in Taiwan: An Application of Meta-Frontier Malmquist Productivity Gap Index

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Abstract. This paper applies the Meta-Frontier Malmquist Productivity Gap Index to analyze the performances and productivity index of banks in Taiwan, for the driven that taking the heterogeneity nature into consideration is quite crucial in calculating the efficiency of banks. In our study, a few conclusions are made: the Taiwan's banks have 0.16% to improve to reach the efficient condition for 2013 to 2017; financial holding banks for whole period own better TE_j value than non-financial holding banks; the group frontier converge to meta frontier at an average speed of 0.075% per year, and its convergence mainly comes from the technical efficient gap change; ΔTEG_j of financial holding banks and non-financial holding banks are both showing convergence for whole period; financial holding banks's technical gap change is smaller than 1 meaning sluggish or regress, while the non-financial enjoys an improvement for whole period.

Keywords: Meta frontier · Meta malmquist productivity gap index model · Bank of Taiwan

1 Introduction

The unprecedented financial bubble in the mid-to-late 1980s of Taiwan and the launch of open policy of financial liberalization have made Taiwan's bank at an unprecedented development speed. In an extremely loose capital environment, the number of banks expanded rapidly, along with the lending standard greatly relaxed which reflected in the ratio of the lending balance of all financial institutions to GDP was as high as 157% in 1994 and 1995. However, due to fierce competition in banks and lack of risk management, after the financial bubble, the asset quality problems of many banks gradually emerged, and the overdue loan ratio of the banking industry began to rise all the way.

The Taiwan authorities opened the establishment of new bank in 1991. Within six years, 16 new banks were set up and three investment trust companies were restructured into commercial banks. In 1995, the Taiwan authorities allowed credit cooperatives to be converted into commercial banks. In 1999, two industrial banks were approved to establish, resulting in a large increase in the number of bank. At the end of

1991, there were merely 24 local banks in Taiwan, however, the number of which was nearly double at the end of 2006 to 44. If we take the foreign bank in Taiwan, credit cooperative, Credit departments of farmers' and fishermen's associations, post office, trust and investment company, and life insurance company in count, the total number of financial institutions and branches in Taiwan will reach 6,385.

The boom of bank's quantity, along with the limited deposit market and the high homogeneity of competitors, resulted in fierce competition in the banking industry. Although this kind of situation can improve operational efficiency, promote business progress, and improve service attitudes of bank, it also reduces the spread of deposits, lowers profit margins, and increases the ratio of over-release. Especially after the 1997 Asian financial crisis, non-performing loan (NPL) has been the most serious problem that Taiwan's banking industry, especially the community financial institutions needed to deal with.

Since 1999, the Taiwan authorities have worked hard to reduce the NPL ratio of the banking industry. By the end of 2002, Taiwan's local banks (including trust and investment companies) had already reduced the amount of bad debts by NT\$974.4 billion, reducing the ratio to 8%, nevertheless, the ratio of Taiwan's community financial institutions is still above 15%.

In the aggressive environment, banks do not hesitate to reduce credit conditions to boost performance, which makes it easy for enterprises to borrow money from banks. However, part of the funds flow to the stock market and real estate, making banks take up considerable credit risks, further deteriorating bank's debt and credit quality.

Besides, after opening credit card business in Taiwan, the issuer strongly promoted to make Taiwan one of the world's fastest growing credit card market in a short time and limit to saturation. Consumer credit over-extended and the loosen control of credit cards resulted in card debt storm in 2005 deteriorated the performance of Taiwan's bank further.

In order to compare the performance of different type of Taiwan's bank, we adopt the conception of malmquist productivity index put up in (Maniadakis and Thanassoulis 2004) combined with the meta frontier model. The structure of the paper is as followed. In Sect. 2, a literature review will be conduct to illustrate the meta-frontier. In Sect. 3, the theoretical concept of meta-frontier approach will be presented to demonstrate the approach applied in our study. Then, Sect. 4 will contains a discussion of our date and variables as well as empirical results. Our main conclusions will be summarized in final section.

2 Literature

Meta-frontier frameworks is derived from the meta-production function which was first introduced by (Hayami 1969) and (Hayami and Ruttan 1970) applied to the agricultural productivity. Based on the hypothesis that different groups have the potential access to the same technology, numbers of works have been showing up to develop the methodology since then. (Gunaratne 2001) extended the meta-production function, where define it as an envelope of all neoclassical production functions where producers are on different micro-production functions due to the differences in adoption and

diffusion of technology, to the stochastic meta-production frontier. (Battese and Rao 2002) and (Battese et al. 2004) extended the SFA approach to the estimation of meta-frontiers, (O'Donnell et al. 2008) especially overcame the problem that in his previous work only consider estimation of the meta-frontier using one type of SFA methodology by extending the framework to consider both of DEA and SFA method.

For the merit of meta-frontier that considering the heterogeneity of DMUs, the meta-frontier framework has seen many applications in different fields, especially in analyzing the efficiency of bank. (Lovell and Pastor 1997) apply it for bank branches in Spain along with target setting, (Azad et al. 2017) use malmquist meta-frontier to look into the Bank efficiency in Malaysia, (Duygun et al. 2016) apply it aiming to investigate the total factor productivity of British commercial banks, and (Huang et al. 2015) compare banking efficiencies in Central and Eastern European countries applying the new meta-frontier directional distance function. In short, the meta-frontier is a reliable and convincing methodology to analyze the efficiency of bank taken the heterogeneity nature of which into consideration.

Furthermore, so as to look into the reason and sources that contributing to the efficiency most, scholars are devoted themselves in decomposing the efficiency index they calculated, for example (Yang and Huang 2009) estimate the malmquist productivity index in the Taiwanese banking industry.

Based on the analysis above, it's easy to find out that taking the heterogeneity nature into consideration by separating the banks into different groups is definitely a crucial part so as to acquire a more convincing and reliable efficiency index of the bank.

3 Methodology

3.1 Malmquist Productive Gap

Consider that in time period t , a decision making unit (DMU) or a university of J group-specific in this study uses N inputs (x^t) to produce M outputs (y^t). Define now the j th group-specific production technology at period t as:

$$P_j^t = \{(y^t, x^t) | x^t \text{ can produce } y^t\} \quad (1)$$

Of which the input requirement sets is defined as:

$$L_j^t(y^t) = \{x^t | (y^t, x^t) \in P_j^t\} \quad (2)$$

Based on (1) and (2), the corresponding input-oriented technical efficiency here is defined as:

$$TE_j^t(y^t, x^t) = \min \left\{ \phi | (\phi x^t) \in L_j^t(y^t) \right\} \quad (3)$$

In contrast to above definition, the meta-technology at period t is defined as the envelope of all J production technologies, i.e., $P_*^t = \text{conv}\{P_1^t \cup P_2^t \cup \dots \cup P_J^t\}$ with the

input requirement sets of the meta-technology is defined as $L_*^t(y^t) = \{x^t | (y^t, x^t) \in P_*^t\}$. The corresponding input-oriented Meta- technical efficiency relative to the meta-frontier is defined in an analogous manner,

$$TE_*^t(y^t, x^t) = \min\{\phi_* | (\phi_* x^t) \in L_*^t(y^t)\} \quad (4)$$

Furthermore, since the Meta-technology envelops all J production technologies, the $L_*^t(y^t)$ is definitely less or equal to $L_j^t(y^t)$, in a similar fashion, the $TE_*^t(y^t, x^t)$ and the $TE_j^t(y^t, x^t)$ have the same relationship, that is:

$$\begin{aligned} L_*^t(y^t) &\leq L_j^t(y^t) \\ TE_*^t(y^t, x^t) &\leq TE_j^t(y^t, x^t) \end{aligned} \quad (5)$$

With reference to (5), the ratio which measures the distance between the two technology frontiers, is called the technology gap (TG), that is:

$$TG_j^t(y^t) = \frac{L_*^t(y^t)}{L_j^t(y^t)} \leq 1 \quad (6)$$

For example, a $TG_j^t(y^t) = 0.8$ implies a potential savings of 20% in input usage to secure the given outputs under the meta frontier. The degree of convergence of the productivity growth toward the potential meta frontier is in term of the growth of $TG_j^t(y^t)$. In addition, the technology gap ratio (TG) can be shown be identical to the technical efficiency gap (TEG) ratio as follow,

$$TEG_j^t(y^t, x^t) = \frac{TE_*^t(y^t, x^t)}{TE_j^t(y^t, x^t)} = TG_j^t(y^t) \quad (7)$$

In the spirit of the conventional Malmquist productivity index, assuming two time periods t and $t + 1$ respectively, the Malmquist productivity gap (MPG) over two time periods can be defined as the geometric mean of the technology gap ratio (TG) in two periods for the sake of avoiding an arbitrary choice of a reference period with reference to alternative technology, so MPG_j is presented as follow:

$$MPG_j = \left[\frac{TG_j^t(y^t+1)}{TG_j^t(y^t)} \times \frac{TG_j^{t+1}(y^{t+1})}{TG_j^{t+1}(y^t)} \right]^{1/2} \quad (8)$$

Thus, when the MPG is greater than 1 it indicates convergence in productivity growth toward metafrontier. The MPG less than one implies divergence and stationary is signaled by MPG equal to 1.

As in the Malmquist productivity index, the MPG can also be decomposed as follow:

$$MPG_j = \frac{TG_j^{t+1}(y^{t+1})}{TG_j^t(y^t)} \times \left[\frac{TG_j^t(y^t)}{TG_j^{t+1}(y^t)} \times \frac{TG_j^t(y^{t+1})}{TG_j^{t+1}(y^{t+1})} \right]^{1/2} \quad (9)$$

The component outside the bracket is the ratio of technology gaps (or the ratio of technical efficiency gaps) in two periods which is called the technical efficiency gap change (ΔTEG_j) as follow:

$$\Delta TEG_j = \frac{TEG_j^{t+1}(y^{t+1}, x^{t+1})}{TEG_j^t(y^t, x^t)} = \frac{TG_j^{t+1}(y^{t+1})}{TG_j^t(y^t)} \quad (10)$$

In a similar fashion, the ΔTEG_j implies convergence in productivity growth toward metafrontier when it is greater than 1, while it less than 1 indicates divergence and stationary comes to the situation that equal to 1.

The component inside the bracket is defined in terms of two TG ratios which compare TG s of producing a given output facing different technology at t^{th} and $(t + 1)^{\text{th}}$ periods. It measures the convergence in technology gap due to technical change, that is,

$$\Delta TG_j = \left[\frac{TG_j^t(y^t)}{TG_j^{t+1}(y^t)} \times \frac{TG_j^t(y^{t+1})}{TG_j^{t+1}(y^{t+1})} \right]^{1/2} \quad (11)$$

Thus, when the ΔTG_j is greater than 1 it indicates convergence in productivity growth toward metafrontier. The ΔTG_j less than one implies divergence and stationary is signaled by ΔTG_j equal to 1. In sum, we have,

$$MPG_j = \Delta TEG_j \times \Delta TG_j \quad (12)$$

4 Results and Discussion

4.1 Data and Variables

This study's data is collected from Taiwan's Economic Daily News (TEJ), lasted from 2013 to 2017, of which the samples is up to 130 including 26 Taiwan's banks. In order to investigate and compare the efficiency of different type of Taiwan's banks, we separate the sample banks into two parts, financial holding banks and non-financial holding banks.

This study adopts the commonly-used intermediation approach to define the input and output variables of the banks. The three input variables are borrowed funds (X_1), fixed capital (X_2) and labor (X_3); in addition to investments (Y_1) and total loans (Y_2), we consider a gradual increase to the weighting of banks' non-traditional business operations, thus non-interest revenues (Y_3) are also listed as a output variable. The variable defined are as Table 1. Meanwhile, we conduct a descriptive statistics of all variables summarized in Table 2.