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IMPACTS OF THE ECONOMIC COOPERATION FRAMEWORK AGREEMENT ON BANKING COST EFFICIENCY IN CHINA AND TAIWAN — A STOCHASTIC METAFRONTIER APPROACH

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Abstract

This study extends the stochastic metafrontier model (SMF) of Huang, Huang and Liu (2014) to compare the meta-cost banking efficiency in China and Taiwan from 2007 to 2013, and to analyze the impacts on cost efficiency following the implementation of the Economic Cooperation Framework Agreement (ECFA). The empirical tests show that the banking sectors in both China and Taiwan implemented distinct technology-related policies during this period. Following the implementation of ECFA, the meta-cost efficiency for Taiwan's banking sectors showed a distinct improvement. Besides, the Chinese banks which had established branches in Taiwan experienced a significant enhancement in meta-cost efficiency. Several managerial insights and implications are discussed.

Keywords: Economic Cooperation Framework Agreement (ECFA), stochastic metafrontier model, cost gap ratio, meta-cost efficiency
JEL Classification Codes: C23, C51, D24, G21, L11

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I. *Introduction*

The current wave of global economic liberalization has driven increased international trade and competition. However, multilateral negotiations within the World Trade Organization (WTO) progress slowly and it is difficult to reach a solid consensus among member states, with individual countries forming commercial alliances to maintain their competitive edge. In recent years, countries have actively developed regional economic integration, and the current trend is towards the formation of Free Trade Agreements (FTAs), which aim to promote economic integration, eliminate trade barriers, and allow the free movement of goods and services between countries. Taiwan is a small, open economy which has developed through the expansion of international trade. China is an emerging economy which occupies an increasingly pivotal role in the global economy. Due to the political discrepancy between Taiwan and China, they have been separated and governed by two different political systems since 1948. However, over the past decade, Taiwan's trade dependence on China has steadily increased[1], and economic and commercial ties between the two sides are growing stronger. The huge trade activities also cause a great demand for financial services. Despite the importance of cross-Strait economic and commercial ties, the cross-Strait integration of financial services is subject to certain restrictions which have prevented Taiwan's financial sector from expanding into China. This has not only slowed down the development of Taiwan's financial industry, but has also placed limitations on Taiwan's ability to successfully promote trade in China. To prevent further restrictions on economic development, on June 29, 2010 Taiwan and China signed the Economic Cooperation Framework Agreement (ECFA) as a new milestone in cross-Strait economic ties.

Banks play an important role in a country's overall economic activity, efficiently converting public savings into investments and loans to promote economic growth and social development. Statistics provided by Chung-Hua Institution for Economic Research show that, in 2012, Taiwan's financial sector accounted for 15.17% of Taiwan's total GDP, and thus the impact of the financial industry on the national economy should not be underestimated. At the same time, financial institutions serve as a mechanism to achieve bilateral international economic relations, and the development of the financial industry plays a key part in the promotion of both domestic economic growth and international affairs. Because it plays such an important role in the financial industry, a good understanding of the characteristics of the banking sector is useful for policy-makers, and the performance of the banking industry can serve as one of the leading indicators of the level of development of the financial sector in a country. Thus, the signing of ECFA has focused public attention on the financial services industry. The respective financial sectors of Taiwan and China operate under different sets of advantages and disadvantages. Their production environments are quite different due to the economic structure and financial market development. China has a huge domestic market, and the markets for insurance, banking and financial products are still relatively undeveloped, providing significant room for further development which has attracted considerable interest from foreign investors. However, this incomplete development is accompanied by underdevel-

[1] The official statistics provided by the Taiwan government show that China's share of Taiwan's international trade increased from 26.6% in 2001 to 40.24% in 2011.

oped market mechanisms and insufficient human resources and expertise. Furthermore, financial services markets are largely concentrated in major cities, thereby further increasing the disparity of wealth. By contrast, Taiwan's financial system is fully developed and the industry features considerable depth of talent and professional skill which has resulted in a wide range of financial products. However, excessive numbers of banks and market saturation have also led to lower returns and higher pastdue loan ratios, resulting in a risk deterioration associated with the banking industry. The political obstacles have also made it difficult to establish ties with other countries, and have raised barriers to entry to China's domestic market. Coupled with the financial crisis and Taiwan's economic underperformance, Taiwanese banks have adopted a more energetic stance to increasing their numbers of branches in China and overcoming the current problem of being undersized.

Measures of efficiency have long enjoyed a great deal of attention from both academia as well as the banking industry in terms of analyzing bank performance and behavior. However, efficiency assessments, whether when using data envelopment analysis (DEA) or the stochastic frontier approach (SFA) to measure performance, have traditionally assumed that decision-making units (DMUs) have similar production technologies. Lau and Yotopoulus (1989) suggested that all producers gradually converge to the same level of production technology, but each DMU adopts different production processes depending on specific circumstances and production resources. In terms of cross-Strait banking operations, significant differences in the production environment due to the regulations, and divergences in political and social development make direct comparisons by pooling all institutions meaningless. Therefore, a common basis of comparison is required to correctly evaluate differences in cross-Strait banking efficiency. Following the implementation of ECFA, Taiwan's government proposed the cross-Strait Agreement on Trade and Services, saying that the agreement would strengthen Taiwan's economy. However, the proposal encountered popular suspicion and resistance because of a lack of actual data indicating that the agreement would deliver economic benefits. Therefore, this paper uses the two-step stochastic metafrontier (SMF) proposed by Huang et al. (2014) and expands it in order to construct a metafrontier cost model to assess cross-Strait banking industry efficiency from 2007 to 2013. Furthermore, this study analyzes changes in cross-Strait banking performance before and after the implementation of ECFA. This two-stage process uses stochastic frontiers to assess the cross-Strait banking industry's country-specific frontier and metafrontier, and decomposes meta-cost efficiencies (MCE) to analyze country-specific cost efficiency (CE) and the cost gap ratio (CGR). The results are expected to facilitate analysis of the differences in cost efficiency between the two countries, and provide insight into ways of reducing their technical differences.

The remainder of this study is organized as follows. Section II presents a brief review of the ECFA and the literature about bank efficiency. Section III sets up the metafrontier cost function model used in this paper. Section IV presents empirical applications and analyzes the results. Section V concludes.

II. *Literature Review*

1. Economic Cooperation Framework Agreement; ECFA

Taiwan has established increasingly close trade relations with East Asian countries, with 65% of exports currently going to China, Japan, Korea and other ASEAN[2] countries, as opposed to 12% to the United States. In recent years, the economic integration in the region has picked up speed, with separate FTAs having been signed with ASEAN, China, Korea and Japan. Most of the countries in the world are also actively pursuing FTAs with their trading partners. However, Taiwan is still unable to fully participate in the region's economic integration, which is seriously marginalizing Taiwan when engaging in foreign trade. To prevent the deterioration in economic relations, the Straits Exchange Foundation and the Association for Relations Across the Taiwan Strait, acting on behalf of the respective governments of Taiwan and China, signed ECFA in Chongqing. ECFA covers trade in goods and services, investment protection, intellectual property rights, defensive measures, economic cooperation and trade dispute settlement mechanisms. In addition to promoting the liberalization of trade in goods, the agreement also promotes the further opening up of trade in services. Structural differences in the financial markets of the two parties include a significant gap in terms of the size of overall markets, institutions and assets. The main consideration contributing to the passage of the agreement is contingent upon certain conditions being met to establish a balance of interests. The expected mutual benefit may rest on the opportunity to eliminate the overly protective market restrictions, adopt a better production technology and effectively broaden the scope of financial markets.Currently, China places limitations on the entry of foreign financial institutions and the scope of their business operations. These limitations create obstacles for Taiwanese banks in China which should be addressed through ECFA negotiations. These negotiations have reached the following conclusions:

(1) Taiwan agrees:

i. To, as soon as possible, rescind OECD conditions on the establishment of Chinese bank branches in Taiwan and equity investment.

ii. To allow qualifying Chinese banks already operating in Taiwan to apply for the establishment of additional branches.

iii. To raisethe shareholding ratio of financial holding companies to 10% (in addition to 15% for Chinese qualified domestic institutional investors) for individual Chinese banks applying for stock market listings in Taiwan, as opposed to 15% for non-listed banks, and 20% for subsidiary banks.

iv. To allow China's Union Pay Corp. to apply to establish branches in Taiwan.

(2) China agrees:

i. When engaging in overseas wealth management operations, Chinese commercial banks can invest in Taiwan financial products.

ii. Qualified Taiwanese banks can apply to establish local banks in China according to

[2] The Association of Southeast Asian Nations.

existing regulations.

iii. Taiwanese banks with branches in Fujian Province can apply to establish additional branches in Fujian according to existing regulations.

iv. To support cross-Strait banking cooperation on equity investments in compliance with relevant regulations.

v. Taiwanese banks operating in China can apply to engage in RMB-based operations for clients including qualified Taiwanese enterprises operating in China.

Therefore, the Taiwan government hopes that the commitments laid out in ECFA can be used to expedite the establishment of Taiwan's banking sector in China and the development of RMB-denominated services, thus promoting the development of Taiwan's banks and ameliorating their financing difficulties. These steps are also expected to allow Taiwan's banks to offer quality financial services to Taiwanese small and medium-sized enterprises operating in China and to expand the overall China market. Tangible results have been achieved in the four years since ECFA was signed. As of 2015, 13 Taiwanese banks had established a total of 17 branches in China (Taiwan Land Bank – Shanghai/Tianjin, Cooperative Bank – Suzhou, Tianjin, Fuzhou, First Bank – Shanghai/Chengdu, Hua Nan Bank – Shenzhen, Changhua Bank – Kunshan/Dongguan, Cathay United Bank – Shanghai/Qingdao, Chinatrust Commercial Bank – Shanghai, Mega– Suzhou, Bank of Taiwan – Shanghai, Yushan Bank – Dongguan, Taiwan Business Bank – Shanghai, Bank SinoPac– Nanjing, Fubon Bank – Shanghai/Shenzhen/Tianjin/Suzhou/Nanjing). Another three banks have established representative offices. At the same time, three Chinese banks (Bank of China, Bank of Communications, and China Construction Bank) have established branches in Taiwan, while one (China Merchants Bank) has established a representative office.

2. Theoretical Basis of the Stochastic Metafrontier

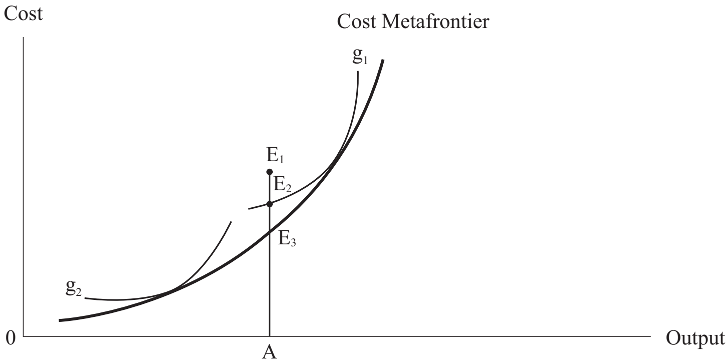
Studies on the issue of bank efficiency use economic theory and mathematical statics to construct the production frontier and have been widely applied. Most previous studies on the issue of bank efficiency apply either DEA or SFA to find the production frontier (Wheelock and Wilson, 1995; Berger et al., 1997; Williams, 2004; Podpiera and Weill, 2008). However, most cross-country studies are usually compared to a common efficient frontier, thereby assuming that banks in different countries can access the same banking production technology. In other words, they assume a common production frontier for all countries in order to be able to compare efficiency results across borders. The interpretation of the resulting efficiency scores relies significantly on the validity of this assumption. The assumption of a common frontier could yield misleading efficiency results of banks from different countries and this is a major drawback, as such approaches do not control for cross-country differences in regulatory and economic development that are beyond a bank's control. Recently, the metafrontier framework, which settled the issue of cross-border efficiency comparisons of banks having different production technology, has drawn much attention in empirical research.

The use of meta-production functions, which are defined as the envelope of group-specific production functions, was introduced in 1969 through the work of Hayami in order to estimate the metafrontier. Battese et al.(2004) proposed a mixed approach with a two-step procedure for estimating the metafrontier. They combined the stochastic frontier (SF) regression used in the first step to estimate the country(group)-specific frontier with the mathematical programming techniques in the second-step to estimate the metafrontier. They also decomposed the meta-technical efficiency (MTE) relative to the metafrontier, which constituted the best practices of the different groups as the product of country(group)-specific efficiency (TE) relative to the own group best practice frontier and technical gap ratio (TGR). Bos and Schmiedel (2007) supported the view that traditional efficiency techniques based on pooled frontier efficiency scores tend to underestimate cost and profit efficiency levels, resulting in biased cross-country comparisons. Berger (2007) found that efficiency scores based on the common frontier model, which is made up of an entire set of nations, tend to be underexamined. By applying the metafrontier, we can establish a very important fact that there exists a difference between the group-frontier and metafrontier, which implies that we may distort the reality of the group-frontier when analyzing the technical efficiencies. O'Donnell et al. (2008) also pointed out the importance of TGR, which can measure the potential improvement in the production environment. Many studies also have applied the metafrontier concept to compare efficiency between China and Taiwan (Huang and Fu, 2013; Chen and Yang, 2011).

However, there are considerable disadvantages to using Battese et al.'s (2004) two-step mixed approach to assess metafrontiers. In the estimation process, the country(group)-specific frontier is calculated to substitute for actual group boundaries, and thus this model lacks a solid theoretical basis. Furthermore, the results of the two-stage metafrontier estimation are still linear (or quadratic) programming algebraic calculations without statistical properties and do not consider error terms. Therefore, Huang et al. (2014) proposed a two-step SMF in which the second step does not use a mathematical planning approach, but still estimates the stochastic metafrontier. In other words, the two-step SMF uses two steps to separately estimate the country(group)-specific frontier and the metafrontier, with efficiency broken down into technical efficiency and a technology gap ratio. Huang et al. (2014) not only used statistical inferences to replace linear and nonlinear mathematical estimation of the country(group)-specific frontier, but also considered error terms and group heterogeneity, thus establishing a model with a more solid theoretical basis. Since SMF still uses traditional maximum likelihood estimation to estimate the stochastic metafrontier parameters, the results obtained can be immediately used for statistical inference. Furthermore, SMF directly views the technology gap as a traditional one-sided error term, and thus it can directly estimate the technology gap, from which the impact of random errors can be separated. The second step of SMF still uses stochastic frontier evaluation, and the technology gap revealed by the one-sided error term can be used to further include uncontrollable environmental variables in the function. This method simultaneously uses environmental variables to construct heterogeneous inefficiencies and enables statistical inferences to be drawn.

Bank efficiency estimates may be influenced by factors not generally included in efficiency analysis, such as differences in bank type, ownership and other specific conditions. Taiwanese and Chinese banks differ significantly in terms of scale, regulatory environment and resources, and thus the production technology differs substantially between them. The pooling estimations can lead to biased efficiency results for banks from different countries as such estimations overlook differences in financial development, competitionand economic conditions which lie beyond a bank's control. Therefore, this paper is based on Huang et al.'s (2014) two-step SMF model, which it extends to a metafrontier cost model to estimate cross-Strait banking meta-cost efficiency.

FIG.1 METAFRONTIER COST MODEL



III. *Methodology*

Assume in time t that the stochastic cost frontier function of the *i*th bank in the *j*th country is defined as:

$$C_{ijt}=f_t^j(X_{ijt},\ \theta_t^j)e^{V_{ijt}+U_{ijt}}\equiv e^{X_{ijt}\theta_t^j+V_{ijt}+U_{ijt}}i=1,2,...,N_{\mathrm{j}}\ ;\ t=1,2,...,T\ ;\ j=1,2,...,J \qquad (1)$$

where C_{ijt} and X_{ijt} are respectively the total cost and matrix input factors of the *i*th bank in the *j*th country in the *t*th period, θ_t^j represents the parameter estimation vector associated with the X vector of the *j*th country; V_{ijt} is the statistical noise assumed to be independently and identically distributed as $V_{ijt}\sim N(0,\ \sigma_v^{j2})$ random variables; the non-negative U_{ijt} represents technical inefficiency and follow a truncated-normal distribution as $U_{ijt}\sim N^+(u^j(Z_{ijt}),\ \sigma_u^{j2})$, and Z_{ijt} represents exogenous environmental variables. As shown in Fig. 1, the meta-cost frontier is the envelope of the country(group)-specific cost frontier, representing the lowest possible cost, such that the meta-cost frontieris less than or equal to the country-specific cost frontier. E_1 is situated in country 1, and thus the country-specific cost efficiency (CE) is measured using AE_2 /AE_1, denoting the *i*th bank's actual cost (E_1) with respect to the distance from the country's optimum cost frontier (g_1), and which can be expressed by Eq.(2). The value of CE is between 0 and 1. When the inefficiency term $U_{ijt}=0$, CE$=$1 indicates that this bank is the most cost-efficient. When the inefficiency term $U_{ijt}\neq 0$, the cost efficiency can be explained by a set of within-country bank-specific exogenous variablesZ_{ijt}.

$$CE_{it}^j=\frac{e^{X_{ijt}\theta_t^j+V_{ijt}}}{C_{ijt}}=e^{-U_{ijt}}\leq 1 \qquad (2)$$

Traditional efficiency measures do not control for similar technology standards and thus cannot obtain the correct indicators for potential efficiency improvement. To prevent this, Huang et al. (2014) proposed the SMF model, which is expanded upon here to implement an empirical analysis of the metafrontier cost function. The metafrontier cost function of all countries in the *t*th period can be calculated as follows:

$$C_{it}^{M}=f_{t}^{M}(X_{ijt},\theta_{t}^{M})=e^{X_{ijt}\theta_{t}^{M}}i=1,2,\ldots,\ N_{\mathrm{j}}\ ;\ t=1,2,\ldots,T \tag{3}$$

Where θ_t^M represents the parameter estimation vector of the metafrontier cost function. The relationship between the country(group)-specific frontier and the metafrontier can be expressed as follows:

$$\ln f_t^j(X_{ijt})=\ln f_t^M(X_{ijt})+U_{ijt}^M \tag{4}$$

Because the metafrontier cost function is a country-specific frontier cost function envelope curve representing the lowest costs, it should not exceed the country-specific frontier cost. At a given input level, the ratio of the ith bank actual cost and its metafrontier cost can be represented as the metafrontier cost efficiency (MCE), thereby combining CE and the cost gap ratio (CGR) as in Eq. (5):

$$MCE_{it}=\frac{C_{it}^{M}}{C_{ijt}}=\frac{e^{X_{ijt}\theta_t^M+V_{ijt}}}{e^{X_{ijt}\theta_t^j+V_{ijt}+U_{ijt}}}=e^{-U_{ijt}}\times\frac{e^{X_{ijt}\theta_t^M}}{e^{X_{ijt}\theta_t^j}}=CE_{it}\times CGR_{it} \tag{5}$$

The metafrontier cost efficiency compares the minimum cost of producing a given output with the observed cost, which is illustrated by AE_3/AE_1 in the figure. An increase to MCE indicates an increase to the cost efficiency calculated using the metafrontier as a benchmark, and thus the ith bank has a relatively optimized cost-savings margin. CGR refers to the ratio of the jth country-specific cost frontier to the cost metafrontier, which is measured by AE_3/AE_2 in the figure. Banks operate in a production environment subject to economic and non-economic factors and select their technologies accordingly. The CGR can analyze the relative cost of the adopted technology to that of the meta-technology and the size of this gap can also be used to compare the degree of cost savings for different countries. A smaller gap indicates that the country-specific frontier is closer to the metafrontier. As CGR approaches 1, the technology of the jth country increases along with the cost savings capacity. Conversely, as CGR approaches 0, the technology of the jth country worsens along with the cost savings ability. The values of CE and CGR lie between 0 and 1, and thus MCE, the product of the two indicators mentioned above, will also be between 0 and 1. Furthermore, decomposition using the above equation allows for easier assessment of the cost effectiveness of banks with the same technology (using CE to make assessments within a single country), as well as with different technology (using CGR to make comparisons across different countries).

The standard maximum likelihood estimation is applied to each country-specific frontier in Eq. (1), i.e.,

$$\ln C_{ijt}=\ln f_t^j(X_{ijt},\ \theta_t^j)+V_{ijt}+U_{ijt}i=1,2,\ldots,N_{\mathrm{j}}\ ;\ t=1,2,\ldots,T\ ;\ j=1,2,\ldots,J \tag{6}$$

Assuming $\hat{f}_t^j(X_{ijt},\ \theta_t^j)$ is the maximum likelihood estimate of the jth country frontier, then the country-specific cost efficiency can be calculated as $\widehat{CE}_{it}=\hat{E}(e^{-U_{ijt}}|\hat{\varepsilon}_{ijt})$. Where $\hat{\varepsilon}_{ijt}=\ln C_{ijt}-\ln\hat{f}_t^j(X_{ijt},\ \theta_t^j)$ are the estimated composite residuals. When calculating $\hat{f}_t^j(X_{ijt})$ this approach considers the error term of calculating $\hat{f}_t^j(X_{ijt})$. The first step uses SFA to estimate each country (group)-specific frontier $\hat{f}_t^j(X_{ijt})$. The country(group)-specific frontier error term V_{ijt}^M is integrated into Eq. (4), which can be rewritten as:

$$\ln \hat{f}_t^j(X_{ijt}) = \ln f_t^M(X_{ijt}) + V_{ijt}^M + U_{ijt}^M \tag{7}$$

$$\ln \hat{f}_t^j(X_{ijt}) = \ln f_t^j(X_{ijt}) + V_{ijt}^M \tag{8}$$

Eq.(7) is similar to the traditional stochastic frontier, and is therefore called the stochastic metafrontier (SMF). Because $\hat{f}_t^j(X_{ijt})$ involves the maximum likelihood estimation of the stochastic frontier obtained by Eq. (1), we can therefore assume that the sampling error term $V_{ijt}^M \sim N(0, \sigma_v^{M2}(Z_{ijt}))$, V_{ijt}^M reflects the differences among heterogeneous groups. The non-negative technology gap $U_{ijt}^M \geq 0$ assumes a truncated normal distribution $U_{ijt}^M \sim N^+(\mu^M(Z_{ijt}), \sigma_u^{M2}(Z_{ijt}))$. The truncated normal distribution $u^M(Z_{ijt})$ is assumed to be a function of the variableZ_{ijt}, and reflects the production environment of the ith bank, in the jth country time t; the heterogeneous variance $\sigma_u^{M2}(Z_{ijt})$ thus reflects the generated uncertainty. This two-step SMF allows us to estimate that the cost metafrontier is smaller than the country-specific cost frontier ($\ln f_t^j(X_{ijt}) \geq \ln f_t^M(X_{ijt})$), to directly estimate the cost gap by treating it as a conventional one-sided error term and allows us to separate the random shocks from the cost gap (Huang et al., 2014).

IV. *Results and Discussion*

1. Stochastic Cost Frontier Function and Variables

Following Battese and Coelli (1995), the stochastic frontier cost function model was used to compare the cost efficiency between Taiwan and China. In addition to considering the interaction between elements and not being subject to the strict separability limitation, the translog function allows for elasticity in terms of feature substitution without the need for presettings, and thus does not require previously-determined production function patterns. Therefore, we use the stochastic frontier cost function model with a time-varying inefficiency effect and specify the translog functional form with trends for analysis. This study adopts the commonly-used intermediation approach to define the input and output variables of the banks. The three input variables are labor (X_1), physical capital (X_2) and borrowed funds (X_3); in addition to total loans(Y_1) and investments(Y_2), we consider a gradual increase in the weighting of banks' non-traditional business operations, and thus non-interest revenues(Y_3) are also listed as an output variable; the labor price (W_1) is employment costs divided by the number of employees; the capital price (W_2) is administrative expenses, depreciation and other expenses divided by capital investment; and the funds price(W_3) is interest payments for all deposits and loans divided by borrowed funds. The cost function is set as follows:

$$\ln C_{ijt}^* = \alpha_0 + \sum_{m=1}^{3} \alpha_m \ln Y_m + \sum_{n=1}^{2} \beta_n \ln W_n^* + \theta_1 t + \frac{1}{2}\sum_{m=1}^{3}\sum_{k=1}^{3} \theta_{mk} \ln Y_m \ln Y_k$$

$$+ \frac{1}{2}\sum_{n=1}^{2}\sum_{k=1}^{2} \gamma_{nk} \ln W_n^* \ln W_k^* + \frac{1}{2}\theta_2 t^2 + \sum_{m=1}^{3}\sum_{n=1}^{2} \rho_{mn} \ln Y_m \ln W_n^*$$

$$+\sum_{m=1}^{3}\delta_m \ln Y_m t+\sum_{n=1}^{2}\lambda_n \ln W_n^* t+V_{ijt}+U_{ijt} \quad (9)$$

Where C_{ijt} is the observed total expenditure, the product of input variables and input price ($C_{ijt}=X_1W_1+X_2W_2+X_3W_3$). This study uses a standardized approach in which the fund price (W_3) is used to deflate C, and W_1 and W_2 are used to impose a homogeneity constraint over the input price. That is, $C_{ijt}^*=C_{ijt}/W_3$, $W_1^*=W_1/W_3$ and $W_2^*=W_2/W_3$; t is the time trend; the distributions and assumption of V_{ijt} and U_{ijt} are the same as those described in Sect. 3.

This study examines balanced panel data from 2007 to 2013 for 34 Taiwanese banks and 35 Chinese banks. The 34 Taiwanese banks sample comprises 9 pan-publicly-owned banks and 25 private banks, and the 35 Chinese banks sample comprises 5 state-owned banks, 20 city commercial banks and 10 national shareholding commercial banks. The total number of observations in the empirical study was 483. The data are mainly sourced from the Bankscope database, Financial Statistics Monthly which is published by the Central Bank of Taiwan and the Almanac of China's Finance and Banking which is published by the National Bureau of Statistics of China. All the nominal variables have been deflated by the annual consumer price index provided by the government statistics of Taiwan and China with the base year being 2010. In addition, the impaired loan ratio, capital adequacy ratio, the logarithm of total assets, the ratio of equity to total assets (TE/TA), the ratio of interest revenue to net profit (IR/NP) and the deposit market share ratio are used as internal financial environmental variables for country-specific cost efficiency. At the same time, real GDP growth rate, money supply growth rate, the Herfindahl index, institutional dummy variable, democracy index and the ratio of government expenditure to GDP are used as external financial environmental variables to explain the gap between country-specific frontier and metafrontier. Each of these variables and descriptive statistics are defined in Tables 1 and 2.

The results in Table 2 not only reveal a significant difference between the two countries in terms of the input and output variables, but also that the input and output variables for Chinese banks are all higher than those for their Taiwanese counterparts, in cases as much as ten times higher, and the average total cost for Chinese banks is seven times that of Taiwanese banks. This shows that while Chinese banking operations are much greater in scale, huge production factors suggest that this scale does not necessarily deliver increased cost efficiency, and this warrants further investigation. Among financial environmental variables, Chinese banks have a higher impaired loan ratio(Z_1), bank size(Z_3), GDP growth rate(Z_7), money supply growth rate (Z_8) and GE/GDP(Z_{12}), but Taiwanese banks outperform in terms of TE/TA(Z_4), IR/NP(Z_5), the Herfindahl index(Z_9) and democracy index(Z_{11}). In addition, no significant difference is found between the two countries in terms of the average capital adequacy ratio(Z_2) and deposit market share ratio (Z_6). In terms of the cost elements, Taiwanese banks have a higher capital price. The average fixed assets (X_2) of Chinese banks are also found to be 6.2 times greater than those of Taiwanese banks. Given the huge amount of fixed assets and the fact that it will take several years to recoup costs, this extensive use of fixed assets induces another issue, namely, whether banks can effectively utilize these fixed assets. This issue requires further analysis.

In addition, it is worth noting that although banks still primarily focus on lending and investment operations, the two countries show a 15-times difference in terms of non-interest revenues, indicating that in the current competitive financial environment, profits from

TABLE 1. DEFINITIONS OF THE VARIABLES

Variable	Definition
Total loans (Y_1)	Loans and total other lending (unit: millions of USD)
Investments (Y_2)	Total earning assets (unit: millions of USD)
Non-interestrevenues (Y_3)	Fee income plus commission income (unit: millions of USD)
Labor input (X_1)	Labor employment (unit: person)
Physical capital (X_2)	Fixed assets less accumulated depreciation (unit: millions of USD)
Borrowed funds (X_3)	The sum of total deposits, total money market funding, and total other funding (unit: millions of USD)
Labor price (W_1)	Personnel expenses / labor input
Capital price (W_2)	(Business and management expenses-labor cost) / physical capital
Funds price (W_3)	(Deposit and loan interest expenditure) / borrowed funds
Turnover	The ratio of stock traded value to stock market value
Imp (Z_1)	The ratio of impaired loans to net loans
Cap (Z_2)	Capital adequacy ratio
ln(TA) (Z_3)	The logarithm of total assets
TE/TA (Z_4)	The ratio of equity to total assets
IR/NP (Z_5)	The ratio of interest revenue to net profit
DMR (Z_6)	Deposit market share rate
GDP (Z_7)	GDP growth rate
MS (Z_8)	Money supply growth rate
Herfindahl index(Z_9)	Sum of the squares of the market shares of the banks within the industry
Institution D(Z_{10})	Institutional dummy variable (Taiwan=1, China=0)
DI (Z_{11})	Democracy index [a]
GE/GDP (Z_{12})	The ratio of government expenditure to GDP

traditional lending and interest operations are shrinking, and many banks are committing to developing non-interest revenue operations. This study considers non-interest revenues to derive correct bank outputs. To determine the significance of variable differences between the two countries, this paper uses the nonparametric Mann-Whitney U-test to determine the differences between groups of banks in the two countries. As shown in the rightmost column of Table 2, for all verification results, except for the labor price, capital adequacy ratio and deposit market share, the other variables exceed the 5% significance level, indicating that a significant difference exists between the two countries in terms of inputs, outputs and environmental variables. Therefore, operating efficiency should be measured.

Table 2. Descriptive Statistics

Variables	Taiwan		China		Test value
	Mean	Std.Dev.[a]	Mean	Std.Dev.[a]	
Total loans(Y_1)	18,517	18,153	161,566	308,889	-7.236***
Investments(Y_2)	5,284	10,822	299,301	570,991	-8.058***
Non-interest revenues(Y_3)	110	135	1,680	3,957	-6.207***
Labor input(X_1)	3,778	2,631	51,480	116,402	-6.413***
Physical capital(X_2)	420	523	2,609	5,658	-6.028***
Borrowed funds(X_3)	25,634	25,522	282,910	538,283	-7.473***
Labor price(W_1)	0.040	0.012	0.038	0.019	1.434
Capital price(W_2)	1.741	6.734	0.773	0.599	3.752***
Funds price(W_3)	0.012	0.007	0.021	0.009	-11.868***
Total cost	1,190	1,904	8,411	15,528	-6.977***
Turnover	0.101	0.029	5.994	1.645	-9.476***
Imp (Z_1)	0.883	0.837	1.894	3.490	-4.403***
Cap (Z_2)	12.533	4.694	12.237	2.428	0.889
ln(TA)(Z_3)	9.796	1.070	10.748	2.116	-6.268***
TE/TA (Z_4)	0.081	0.073	0.061	0.021	3.909***
IR/NP (Z_5)	17.001	94.916	3.747	3.484	2.147**
DMR (Z_6)	0.028	0.027	0.026	0.053	0.238
GDP(Z_7)	0.034	0.038	0.097	0.020	-12.894***
MS(Z_8)	0.077	0.094	0.154	0.089	-9.303***
HI (Z_9)	0.140	0.002	0.057	0.006	20.270***
DI (Z_{11})	7.625	0.148	3.069	0.581	75.81***
GE/GDP (Z_{12})	0.183	0.011	0.214	0.018	-3.941***

Note: [a] 'Std. Dev.' is "standard deviation"
*** Significant at the 1% level; ** Significant at the 5% level
Total loans, investments, non-interest revenues, borrowed funds, physical capital, labor price, funds price, capital price and total cost are denoted in millions of USD. Labor input is denoted in persons.

2. Translog Function Estimation Results

The translog cost function incorporates the time entry to capture changes in technical efficiency, where the technical inefficiency assumption is a function of environmental parameters (Battese and Coelli, 1995), that is, $U_{ijt} \sim N^{+}(u^{j}(Z_{ijt}), \sigma_{u}^{j2})$, where $u(Z_{ijt})$ assumes a linear function of the variable Z_{ijt}. Table 3 shows the estimation results for each parameter. When using pooling to generate frontiers, we assume that all samples have the same technology standards, and thus we cannot guarantee that the estimated metafrontier can envelop all country-specific frontiers. Therefore, the efficiency measures derived from pooling methods are meaningless. Furthermore, we must clarify in advance whether these two countries share a common technology level. If all sample banks are on an identical production frontier, it implies that they use the same technology. However, the pooled frontier's log likelihood test statistical measure is 68.443, or 43.035 and 213.508, respectively, for Taiwanese and Chinese banks. This indicates that we can reject the null hypothesis for the technology similarity restriction[3]. This indicates that the sample banks for the two countries do not share a technology level, and calculating the individual cost frontiers demonstrates that there is a significant technology gap between the sample banks, thus necessitating a further estimation of the cost metafrontier.

Since the stochastic cost frontier includes a statistical noise V_{ijt} and a non-negative U_{ijt} represents inefficiency, which follows the truncated-normal distribution, the combined error term of the cost frontier is $\varepsilon_{ijt}=v_{ijt}+u_{ijt}$. When all banks are efficient, $U_{ijt}=0$, indicating that the samples are located on the efficiency frontier. That is, the efficiency score is equal to 1. At the same time, it also indicates that inefficiencies do not exist. Therefore, this paper verifies whether or not inefficiencies exist. The null hypothesis H_0 is that "inefficiencies do not exist". γ^jrepresents the percentage of the total variance accounted for by the inefficiency error. As seen in Table 3, for both Taiwanese and Chinese banks, where the value of γ^j is less than the 1% significance level, the null hypothesis "inefficiencies do not exist" is rejected. In other words, the values of γ^j for Taiwan and China are 0.746 and 0.978, which indicates that about 74.6% and 97.8% of the composite is due to management inefficiency. This indicates that there are indeed differences in the level of efficiency for banks between the two countries, and the efficiency value should be calculated for each bank.

Table 3 shows that the estimated results for most parameters meet the significance criteria. The lower part of the table lists estimation results for the internal financial environmental parameters[4]. The impaired loan ratio (Z_1) coefficient is significant and positive, implying that a higher impaired loan ratio imposes additional expenses on banks for the disposal of bad loans, thus eroding bank profits and having a negative impact on costs (Berger et al., 1997; Goodhart et al., 2004); the capital adequacy ratio (Z_2) coefficient is significant and negatively associated with inefficiency, indicating that banks with a sound capital structure have incentives to operate efficiently (Kwan and Eisenbeis, 1997); the coefficient of the logarithm of total assets (Z_3) is significant and negatively associated with inefficiency, showing an increase in total bank assets, and thus banks are better able to allocate assets in response to market price volatility and thus respond more rapidly to events, which has a positive effect on cost efficiency (Yang and Huang, 2009). Finally, the coefficient for the deposit share of Taiwanese banks (Z_6) is significant and positively associated with inefficiency, possibly due to Taiwan's small margins – if a bank commits a larger share of its deposits to financial markets, it may have trouble finding a suitable layout for funding or investment opportunities, thus negatively impacting its costs.

The last column in Table 3 shows the two-step SMF estimation results. The γ^M value of the stochastic metafrontier is 0.932 achieving significance at the 1% level, and indicating that this sample exhibits cost inefficiency. Therefore, we cannot simply use the ordinary least squares method for analysis, and we apply a two-step SMF to obtain optimized estimation. The SMF inefficiency term (U_{ijt}^M) assumes that the external financial environmental parameter

[3] Likelihood ratio test: H_0: the frontiers of the Taiwanese and Chinese banks are identical; H_1: the frontiers of the Taiwanese and Chinese banks are distinct. The LR statistic is defined by $\lambda=-2\{\ln[L(H_0)]-\ln[L(H_1)]\}$, where $[L(H_0)]$is the value of the log-likelihood function for the frontier estimated by pooling all the banks, while $[L(H_1)]$ is the sum of the values of the log-likelihood functions for the two group frontiers.
$L-LR\chi^2_{(0.05,32)}=46.1701$

[4] An environmental variable in the first step has a positive (negative) coefficient indicates that the variable make a negative (positive) influence on group-specific cost efficiency.

TABLE 3. STOCHASTIC COST FRONTIER ESTIMATIONS FOR BANKS IN TAIWAN AND CHINA

	Taiwan[c]	China[c]	Pooling[ac]	SMF[bc]
constant	10.509*** (2.266)	-1.545* (0.805)	-1.429*** (0.782)	0.2541 (0.699)
$\ln Y_1$	-0.601 (0.540)	-1.160** (0.492)	1.298*** (0.218)	1.799***(0.128)
$\ln Y_2$	-0.129 (0.222)	2.260***(0.457)	-0.015 (0.159)	-0.797*** (0.087)
$\ln Y_3$	0.141 (0.417)	-0.155***(0.047)	0.013(0.065)	-0.044(0.045)
$0.5\times\ln Y_1\times\ln Y_1$	0.072 (0.079)	-0.041(0.319)	-0.114***(0.038)	-0.217*** (0.022)
$0.5\times\ln Y_2\times\ln Y_2$	0.028 (0.022)	-0.103(0.316)	0.098***(0.015)	0.018(0.009)
$0.5\times\ln Y_3\times\ln Y_3$	-0.097***(0.044)	0.007***(0.002)	0.008***(0.004)	0.013*** (0.003)
$\ln Y_1\times\ln Y_2$	-0.018 (0.029)	0.084(0.316)	-0.008 (0.022)	0.097***(0.013)
$\ln Y_1\times\ln Y_3$	0.145*** (0.057)	-0.003 (0.019)	0.096***(0.010)	0.105***(0.006)
$\ln Y_2\times\ln Y_3$	-0.048***(0.018)	0.012 (0.002)	-0.098***(0.010)	-0.103*** (0.006)
$\ln W_1$	1.032 (0.685)	0.116 (0.300)	0.037(0.278)	0.318 (0.206)
$\ln W_2$	-0.490 (0.315)	0.507**(0.207)	0.223 (0.181)	0.048 (0.142)
$0.5\times\ln W_1\times\ln W_1$	0.041 (0.135)	0.191** (0.079)	0.051 (0.077)	0.163*** (0.056)
$0.5\times\ln W_2\times\ln W_2$	0.135*** (0.026)	0.006 (0.029)	0.030(0.024)	0.076***(0.016)
$\ln W_1\times\ln W_2$	0.089* (0.047)	-0.017(0.042)	0.113***(0.035)	0.071*** (0.024)
$\ln Y_1\times\ln W_1$	-0.271***(0.084)	-0.073 (0.091)	-0.121***(0.042)	-0.097***(0.028)
$\ln Y_1\times\ln W_2$	0.006 (0.041)	0.249***(0.086)	0.016 (0.019)	-0.037*** (0.014)
$\ln Y_2\times\ln W_1$	0.067* (0.040)	0.077 (0.094)	0.093***(0.028)	-0.042** (0.019)
$\ln Y_2\times\ln W_2$	0.053*** (0.019)	-0.275*** (0.084)	-0.034**(0.018)	0.027** (0.011)
$\ln Y_3\times\ln W_1$	0.111 (0.072)	-0.025** (0.012)	-0.013(0.016)	-0.014(0.012)
$\ln Y_3\times\ln W_2$	-0.061***(0.029)	0.023***(0.007)	0.021*** (0.008)	0.026***(0.006)
t	-0.080 (0.217)	0.169*** (0.066)	0.123*(0.072)	0.215***(0.054)
$0.5\times t^2$	-0.032***(0.010)	-0.007 (0.005)	-0.014***(0.003)	0.001(0.002)
$t\times\ln Y_1$	0.097*** (0.026)	-0.003 (0.037)	0.037***(0.010)	0.007(0.007)
$t\times\ln Y_2$	-0.025*(0.013)	-0.073(0.037)	-0.033*** (0.008)	-0.019***(0.005)
$t\times\ln Y_3$	-0.046* (0.024)	0.004 (0.002)	0.004(0.003)	0.005**(0.002)
$t\times\ln W_1$	0.039 (0.042)	-0.011 (0.013)	-0.040***(0.020)	-0.010(0.015)
$t\times\ln W_2$	-0.048*** (0.017)	-0.015 (0.009)	-0.022***(0.009)	-0.033***(0.007)
Country-specific environmental variables				
constant	3.778***(1.131)	2.716***(0.322)	3.675*** (0.354)	-3.270***(0.783)
Z_1	0.117* (0.062)	0.094*(0.006)	0.003 (0.008)	
Z_2	-0.068***(0.024)	-0.028***(0.014)	-0.022***(0.006)	
Z_3	-0.315*** (0.087)	-0.151*** (0.019)	-0.208***(0.023)	
Z_4	1.596(1.426)	2.217** (1.004)	0.934*** (0.109)	
Z_5	-0.001*** (0.000)	0.003 (0.005)	0.001 (0.002)	
Z_6	20.320***(4.056)	2.788 (1.779)	7.997***(0.093)	
$\sigma^{j2}=\sigma_v^{j2}+\sigma_u^{j2}$	0.889*** (0.116)	0.044*** (0.004)	0.072***(0.007)	
$\gamma^j=\sigma_u^{j2}/(\sigma_v^{j2}+\sigma_u^{j2})$	0.746*** (0.116)	0.978***(0.001)	0.928*** (0.051)	
log likelihood	43.035	213.508	68.443	
Second-step environmental variables				
constant				-4.707*** (1.613)
Z_7				-8.713***(1.260)
Z_8				-5.448***(0.961)
Z_9				-8.793***(2.121)
Z_{10}				1.041(0.911)
Z_{11}				-0.266(0.204)
Z_{12}				-31.870***(6.863)
$\sigma^{M2}=\sigma_v^{M2}+\sigma_u^{M2}$				0.178***(0.026)
$\gamma^M=\sigma_u^{M2}/(\sigma_v^{M2}+\sigma_u^{M2})$				0.932***(0.014)
log likelihood				211.051

Note: [a] All the banks are used to estimate the stochastic frontier regardless of the country of the technological difference.

[b] SMF refers to the 'stochastic metafrontier'.

[c] The figures in the parentheses are the standard deviations.

*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level function, $U_{ijt}^{M} \sim N^{+}(\mu^{M}(Z_{ijt}), \sigma_{u}^{M2}(Z_{ijt}))$, and $\mu^{M}(Z_{ijt})$ is a linear function of the industry-specific environmental variable Z_{ijt}. This paper adopts the GDP growth rate (Z_7), money supply growth rate (Z_8), the Herfindahl index(Z_9), institutional dummy variable(Z_{10}), democracy index(Z_{11})[5] and the ratio of government expenditure to GDP(Z_{12}) as second-step environmental variables[6]. Table 3 shows that the negative coefficient estimate of Z_7 indicates that the higher GDP growth rate of the country, the closer it production frontier is to the metafrontier. Z_8, Z_9 and Z_{12} are all significant and negative associated with cost gap, indicating that a loose monetary policy, higher concentrated of the bank industry and higher ratio of government expenditure to GDP will shorten the difference between the country-specific frontier and metafrontier. From this, environmental differences indeed play an important role in determining cost gap and should be included in the model to properly assess a bank's technology. Failing to take into consideration the external financial environmental variables will result in a miscalculation of *CGR* and *MCE*. Moreover, models which consider external financial environmental differences can be used to estimate the differences in cost efficiency for banks at different technology levels (Huang et al., 2014).

3. MCE, CE and CGR Estimates

Table 4 shows the estimation results for MCE, which is the cost efficiency computed using the metafrontier as the benchmark frontier, for all banks observed. The metafrontier which envelops all observations can investigate the technical efficiencies of banks in different countries that may not have the same technology. An *MCE* value of 1 means that a bank's relative efficiency is located on the efficient metafrontier of all banks. During the study period, the CE scores for Taiwanese and Chinese banks are respectively 0.894 and 0.845, leaving 10.6% and 15.5% room for improvement, respectively. Observing changes to CE before and after the signing of ECFA shows that Taiwanese and China's banking industry increased from 0.873 to 0.911 and 0.808 to 0.873, implying a post-ECFA CE enhancement of 3.8% and 6.5%, respectively. Although Taiwan's banks show a CE improvement, the range is smaller than Chinese banks. For the cross-Strait banking industry, these results indicate that either the banks use excess inputs to produce a given output or use an improper input mix at the prevailing input price levels, or both.

The CGR expresses the distance between the metafrontier and the country-specific frontier. When the CGR is close to 1, the gap is smaller, implying convergence of that country-specific frontier to the metafrontier. The results indicate that the CGR score of Taiwanese banks is larger than that of Chinese banks (0.908 vs. 0.865). After ECFA was signed, Taiwanese banks (CGR = 0.916) were observed using more optimal operating technology than Chinese banks (CGR=0.853), thus Taiwanese banks converge more closely to the cost metafrontier, implying that they have more optimal technology and cost savings ability. In addition, the CGR of Taiwanese banks is seen to increase from a pre-ECFA value of 0.898 to 0.916 after the

[5] The Economist Intelligence Unit's index of democracy, on a 0 to 10 scale, is based on the ratings for 60 indicators grouped in five categories: electoral process and pluralism; civil liberties; the functioning of government; political participation; and political culture. Each category has a rating on a 0 to 10 scale, and the overall index of democracy is the simple average of the five category indexes.

[6] The environmental variable in the second step that has a positive (negative) coefficient indicates that the variable promote a larger (smaller) technology gap between the country-specific frontier and the metafrontier.

Table 4. Summary Statistics of Cost Efficiency Measures

		CE				CGR				MCE			
		Mean	Std.Dev.[a]	Max	Min	Mean	Std.Dev.[a]	Max	Min	Mean	Std.Dev.[a]	Max	Min
Panel A *CE*, *CGR* and*MCE* measures for all banks in Taiwan and China													
Taiwan	Before signingECFA	0.873	0.110	0.976	0.367	0.898	0.082	0.977	0.511	0.783	0.120	0.934	0.354
	After signingECFA	0.911	0.086	0.972	0.355	0.916	0.065	0.972	0.467	0.834	0.098	0.932	0.314
China	Before signing ECFA	0.808	0.142	0.998	0.289	0.882	0.084	0.976	0.476	0.714	0.146	0.923	0.271
	After signing ECFA	0.873	0.106	0.998	0.521	0.853	0.112	0.982	0.304	0.744	0.135	0.935	0.280
Overall	Taiwan	0.894	0.099	0.976	0.355	0.908	0.073	0.977	0.467	0.812	0.111	0.934	0.314
	China	0.845	0.127	0.998	0.289	0.865	0.102	0.982	0.304	0.732	0.140	0.963	0.271
Panel B *CE*, *CGR* and*MCE* measures for banks with cross-Strait branches													
Taiwan	Before establishing branches	0.830	0.143	0.944	0.367	0.912	0.084	0.976	0.511	0.756	0.150	0.916	0.354
	After establishing branches	0.876	0.126	0.965	0.356	0.917	0.042	0.970	0.767	0.803	0.121	0.914	0.314
China	Before establishing branches	0.881	0.047	0.950	0.804	0.893	0.043	0.953	0.814	0.786	0.044	0.881	0.718
	After establishing branches	0.931	0.036	0.985	0.869	0.902	0.046	0.954	0.810	0.836	0.056	0.935	0.729

Note: [a]'Std. Dev.' is 'standard deviation'

agreement was signed. Despite this improvement of 1.8%, it is implied that, post-ECFA, the technology capabilities of Taiwanese banks was enhanced. On the other hand, the CGR results show that China's banking industry declined from 0.882 to 0.853, revealing a post-ECFA CGR deterioration of 2.9%. The results of MCE scores, defined as the product of $CE \times CGR$, indicate that the MCE of Taiwanese banks (0.812) is superior to that of Chinese banks (0.732). Further measurement of the correlation between MCE and CGR shows a result of 0.623, implying that if the difference between the country-specific frontier and metafrontier shrinks, then the MCE increases. Comparing performance before and after ECFA for the two countries shows that the MCE of Taiwanese banks improved from 0.783 to 0.834 with the signing of the agreement. On the other hand, the drop in the CGR of Chinese banks resulted in their MCE having slightly improved (MCE=0.714 and 0.744), showing that the adoption of ECFA did not include a thorough examination of bank operations and cost control mechanisms, resulting in the MCE only improving slightly after the agreement was signed.

Despite broad claims that ECFA will promote the development of the banking industry in both Taiwan and China, to date accumulated benefits have been disappointing. As of 2015, only 13 Taiwanese banks and three Chinese banks had established branches in China and Taiwan, respectively. It is worth examining the effects of ECFA on the cross-Strait banks. This study further examines changes in cost efficiency before and after the establishment of these cross-Strait branches. Chinese banks which had established branches in Taiwan experienced an improvement in CE (from 0.881 to 0.931), CGR (from 0.893 to 0.902) and MCE (from 0.786 to 0.836). The Taiwanese banks establishing branches in China also exhibited an enhancement in CE, CGR and MCE. A larger bank CGR value implies that the country-specific cost frontier is closer to the meta-cost frontier. On average, the improved range of Chinese banks (from 0.893 to 0.902) is larger than Taiwanese banks (from 0.912 to 0.917). This catch-up effect can be regarded as the more rapid movement of the Chinese banks' cost frontier towards the meta-cost frontier than that of the Taiwanese banks after the establishment of branches on the opposite side of the Strait.

This study further uses Tobit regression, which takes into account the censored nature of the dependent variable, to explore the determinants of meta-cost efficiency. The independent

TABLE 5. RESULTS OF TOBIT REGRESSIONS ON THE DETERMINANTS OF BANK EFFICIENCY

	All Banks		Banks with cross-Strait branches	
	Taiwan	China	Taiwan	China
Constant	0.784*** (0.041)	0.722*** (0.038)	0.839*** (0.025)	0.831*** (0.031)
ECFA	0.043** (0.021)	0.020 (0.027)	0.023 (0.040)	0.091*** (0.031)
D_{2008} [a]	-0.031 (0.026)	-0.022 (0.039)	-0.064 (0.016)	-0.068 (0.044)
D_{2009} [b]	-0.065** (0.029)	-0.007 (0.050)	-0.065* (0.036)	-0.085* (0.050)
Turnover [c]	0.084 (0.357)	0.001 (0.009)	0.683 (0.692)	0.015* (0.009)
R^2	0.305	0.212	0.223	0.286
Observation	238	245	91	28

Note: [a] Dummy variable: 2008=1, others=0;
[b] Dummy variable: 2009=1, others=0;
[c] Turnover: the ratio of stock traded value to stock market value
The figures in the parentheses are the standard deviations
*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level

variables included are ECFA dummy variable, time dummy variable (D_{2008} and D_{2009}) and the ratio of stock traded value to stock market value. The ECFA dummy variable (before=0, after=1) is included to test for possible impact on MCE among the two countries. In order to highlight the effects of the financial tsunami on MCE, we include the time dummy variables D_{2008} (2008=1, others=0) and D_{2009} (2009=1, others=0). Besides, the recent literature links financial development to economics efficiency and productivity growth (Kasman and Yildirim, 2006). The stock market is an economic foundation, which promotes efficiency in capital formation and allocation. This study uses turnover variable, which is defined as the ratio of stock traded value to stock market value, as a proxy to capture the countries' financial structure.

The Tobit regression is constructed as follow:

$$MCE=\beta_0+\sum_{j=1}^{4}\beta_j X_j+\varepsilon_j \qquad (10)$$

where X_j refers to the variables of ECFA, D_{2008}, D_{2009} and Turnover.

The results of the regression estimations illustrate some interesting findings on the determinants of meta-cost efficiency. Taking ECFA variable first, the coefficient is positive and significant at 5% for Taiwanese banks but not significant for Chinese banks. Evidence appears to support that the adoption of ECFA in Taiwan experienced a significant improvement in MCE. Though the coefficient on D_{2008} don't reach significant level, the negative sign in all regressions imply that the financial tsunami resulting from the declaration of bankruptcy of Lehman Brothers in 2008 had a severe impact on the meta-cost efficiency. However, the coefficients of D_{2009} are significantly negative, showing that the financial tsunami has a negative sustained effect on MCE. We now turn to the effect of banks with cross-Strait branches. Chinese banks which had established branches in Taiwan experienced a significant improvement in MCE after ECFA was signed. However, Taiwanese banks establishing branches in China don't reach the significant level after the signing of the agreement. Table 5

TABLE 6. *CE*, *CGR* AND *MCE* MEASURES FROM 2007 TO 2013

Year	Taiwan		China	
	MCE	*CE*×CGR	*MCE*	*CE*×CGR
2007	0.793	0.868×0.914	0.732	0.786×0.922
2008	0.823	0.871×0.949	0.702	0.814×0.862
2009	0.731	0.879×0.832	0.717	0.825×0.864
2010	0.839	0.903×0.928	0.704	0.816×0.861
2011	0.804	0.912×0.883	0.715	0.869×0.822
2012	0.855	0.910×0.940	0.808	0.904×0.834
2013	0.838	0.918×0.913	0.749	0.901×0.834
All	0.812	0.839×0.908	0.732	0.846×0.865
K-W test[a]	50.258***	25.621 ***103.377***	14.866**	25.079***37.773***

Note: [a] 'K-W test' is the Kruskal-Wallis test
*** Significant at the 1% level; ** Significant at the 5% level

TABLE 7. THE RESULTS OF THE WILCOXON RANK SUM TEST

Year	Taiwan[a]			China[a]		
	CE changes[b]	*CGR* changes[b]	*MCE* changes[b]	*CE* changes[b]	*CGR* changes[b]	*MCE* changes[b]
2007 vs.2008	0.003 (-0.573)	0.034 (-4.043***)	0.032 (-2.419**)	0.028 (-1.884*)	-0.060 (-3.702***)	-0.021 (-0.852)
2008 vs.2009	0.009 (-0.368)	-0.117 (-5.069***)	-0.094 (-4.344***)	0.011 (-0.213)	0.002 (-0.147)	0.015 (-0.213)
2009 vs.2010	0.024 (-4.556***)	0.097 (-4.590***)	0.108 (-4.864***)	-0.009 (-0.983)	-0.003 (-0.131)	-0.014 (-0.557)
2010 vs.2011	0.008 (-1.616)	-0.046 (-3.667***)	-0.035 (-2.009**)	0.054 (-4.291***)	-0.039 (-1.818**)	0.011 (--0.557)
2011 vs.2012	-0.001 (-1.274)	0.057 (-4.625***)	0.052 (-3.308**)	0.035 (-2.735***)	0.072 (-3.210***)	0.092 (-3.505***)
2012 vs.2013	0.008 (-1.342)	-0.027 (-2.419**)	-0.017 (-1.906*)	-0.004 (-1.228)	-0.059 (-2.932***)	-0.059 (-2.899***)

Note: [a] the figures in the parentheses are Z test scores
[b] *CE* changes, *CGR* changes and *MCE* changes: average annual value less the average value for the previous year
*** Significant at the 1% level; ** Significant at the 5% level; * Significant at the 10% level

also reveals a significantly positive impact of turnover variable on MCE for Chinese banks which had established branches in Taiwan. It implies that a further promotion of the financial stock market will enhance the banks' meta-cost efficiency. These results show that although it had been claimed that ECFA was promoting the development of the banking industry in both Taiwan and China, the accumulated benefits are far less impressive than expected.

The empirical results above show that the CE, CGR and MCE of Taiwan's banking industry outperform their counterparts for China. This paper further uses the Kruskal-Wallis test for each efficiency value to determine the significance level of the difference for each year. The results are listed in Table 6, showing that the MCE, CGR and CE reach the 5% level of significance for both two countries. It is worth noting that the CGR of Taiwanese banks and Chinese banks reaches the 1% significance level, indicating that differences exist for CGR in each year, but further tests are needed to determine whether this actually resulted in annual improvements to technical capacity. Therefore, this paper further uses the Wilcoxon rank sum test to detect annual changes in CGR. Table 7 shows the test results for the average annual value less the average value for the previous year. For 2007/2008, 2009/2010 and 2011/2012, Taiwanese banks reveal a significant and positive change in CGR, indicating that in these years Taiwan's technical capacity for cost savings increased. Besides, for 2011/2012, Chinese banks exhibited significant progress in CGR, indicating that there was a significant improvement in cost savings. In other words, the cost technological catch-up ability of the cross-Strait banking sector was enhanced in these years.

V. *Conclusion*

By entering into the ECFA negotiations with China, Taiwan hoped to reestablish its international competitiveness and avoid its being economically marginalized. Despite a relatively late start, China's economic development has proceeded at breakneck speed, and neighboring countries including Japan and Korea are actively seeking to create advantages for themselves through cooperation with China. Taiwan's geographical location and culture offers it significant and unique advantages. Economic development began relatively early in Taiwan and, in the process, has developed rich experience and expertise. However, Taiwan is a small country with few resources, especially in comparison with China. Combining Taiwan's expertise with China's size and resources could quickly improve the commercial effectiveness of both countries. However, the relationship is characterized by political conflict between Taiwan and China and divergent national interests. Taiwan's government has promoted the potential benefits of ECFA, but the people of Taiwan remain skeptical. Therefore, this paper adopts the SMF approach proposed by Huang et al. (2014) to estimate the MCE, CE and CGR for Taiwanese and Chinese banks from 2007 to 2013 to assess changes in cost efficiency that coincide with the enactment of ECFA. It is hoped that the rigorous efficiency assessment and analysis applied here to cross-Strait banking operations will provide a valuable reference to financial institution executives and supervisory agencies.

This study has found that cross-Strait banking inputs, outputs and environmental variables show that significant differences exist between the two countries, and that only the labor price, capital adequacy ratio and deposit market share failed to meet the significance criteria, while all other variables reached significance at the 5% level. The stochastic cost frontier estimation results show that Taiwanese and Chinese banks indeed have different stochastic cost frontiers, and that a technology gap exists between the two countries' banks which would be better analyzed using the metafrontier model. The translog function estimation results show that a higher ratio of impaired loans and deposit market share will impose greater costs on banks. In addition, an increased capital adequacy ratio and asset scale will reduce bank costs inefficiency, while increased economic growth, loosen monetary policy, stronger market exclusivity and higher ratio of government expenditure to GDP will also narrow the gap between country-specific frontier and metafrontier. The efficiency estimate results show that the country-specific cost efficiency, cost gap ratio and meta-cost efficiency of the Taiwanese banking sector are superior to those for China's banks. Following the implementation of ECFA, the meta-cost efficiency for Taiwan's sectors showed a distinct improvement. The empirical results also show that the Chinese banks which had established branches in Taiwan experienced a significant enhancement in terms of MCE. Significant differences were found during the study period in terms of the MCE, CE and CGR in each of the two countries' banking sectors. In addition, during partial study period, the changes in the CGR were positive, indicating that there was an upward trend in terms of the cost savings capacity in each of the two countries.

The signing of ECFA opens up the possibility for China to learn from Taiwan's financial experience and expertise to make up for its own shortcomings. Relaxing restrictions on the establishment of Taiwanese bank branches in China could accelerate and improve the development of China's banking industry while enhancing China's expertise. Taiwan can potentially leverage the agreement to inject funds into China's financial markets, thereby optimizing the utilization of funds and improving meta-cost efficiency. Therefore, given the importance of a better understanding of cross-Strait financial industry strengths and weaknesses and overall market conditions, the collaboration can leverage the links created by ECFA to provide mutual benefits and strengthening.

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