Print ISSN: 2288-4637 / Online ISSN 2288-4645
doi:10.13106/jafeb.2020.vol7.no10.783

Evaluation and Comparison of Bank Efficiency in Cross-Strait after ECFA

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Received: August 01, 2020 Revised: September 06, 2020 Accepted: September 11, 2020

Abstract

The purpose of this study is to investigate whether the ECFA impacted the efficiency of banks in China and Taiwan from 2008 to 2017. This study follows Seiford and Zhu (2002), who recommend using the standard data envelopment analysis model to measure performance by increasing the desirable outputs and decreasing the undesirables. The finding was that overall technical efficiency increased from 2012 to 2017, reaching 0.575, 0.652, 0.617, 0.689, 0.701 and 0.74, respectively. This result implies bank efficiency did indeed improve after China and Taiwan signed the ECFA cooperation agreement. The study found that the mean technical efficiency was 0.8756 in China, greater than Taiwan's mean of 0.3511, implying that Chinese banks experienced a greater increase in efficiency after signing the ECFA. One possible reason explored in this study is that China's economy is currently growing at the highest rate in the world, and the banks' efficiency has benefited from greater economic growth. This suggests that cross-strait sustained negotiations to consummate an agreement on trade in the services will be a very important mission in the future. This result also provides significant evidence suggesting that not accounting for undesirable output while estimating the evolution of the model may seriously distort efficiency results.

Keywords: Cross-Straits Economic Cooperation Framework Agreement (ECFA), World Trade Organization, Data Envelopment Analysis

JEL Classification Code: F36, G21, P52

1. Introduction

The Straits Exchange Foundation of Taiwan and the Association for Relations Across the Taiwan Straits of China signed the Cross-Straits Economic Cooperation Framework Agreement (ECFA) in Chongqing on June 29, 2010. This agreement represents cross-strait (China and Taiwan) economic cooperation stepping up to a new stage, ECFA is only a framework agreement, and the parties need to begin negotiations on four follow-up agreements. According to the early harvest plan in service relative to banking and other financial services, the cross-strait financial regulator allows counterpart banks to have entry to the host market. Levine (1996) argued that foreign bank entry improves the quality and availability of financial services in the

host financial market by increasing bank competition and enabling the greater application of more modern banking skills and technology. Thus, the bilateral banks' entry to the counterpart's financial market improved the banks' efficiency after ECFA, especially for the Chinese banking industry.

China and Taiwan are still emerging countries, relative to bank management, and business activity is rigorously regulated compared with developed countries. The Taiwanese regulator, due to increased banking efficiency and competitiveness, has deregulated relative to the restrictive banking industry norms of the early 1990s. The previous literature has shown banks are lower efficiency in Taiwan. Liao (2018) empirical results showed banks' mean technical efficiency score was 0.61 in Taiwan. A similar result from Peng et al. (2017) showed that banks' cost efficiency was 0.605 for the period 2004-2012. They have suffered from scale inefficiency, lower profitability, and a large volume of non-performing loans (NPL) in the last two decades. Similar problems exist in China, driving the regulators to accelerate and deepen banking reform policies, as domestic banks have had to compete with foreign banks on a level playing field beginning in 2007 due to the rules and obligations set by the WTO. Dong et al. (2016) showed that cost and profit efficiency levels are on average, around

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70% in China for the period 2002–2013. This study also attempts to explain whether improved efficiency after the period of financial reform was possibly due to enhanced bank efficiency, improved risk management practices, and the benefits obtained from complying with the financial reform for China and Taiwan.

In conclusion, this study offers three important contributions. First, in accounting for both desirable and undesirable output while evaluating and analyzing bank efficiency, it assumes that undesirable outputs operate as NPL and offers a comparison of different results from perspectives that either consider undesirable output within the classical Data Envelopment Analysis (DEA) model or do not. The second contribution stems from the fact that the processes of fast growth and recovery in the last two decades have given emerging Asian countries undoubtedly key roles in world economics, and studies have responded by analyzing data of emerging Asian countries, such as China and Taiwan, and gathered results for various management, economics, and financial management topics. However, if NPL were not included in estimates, the DEA model could operate with severe bias, especially by neglecting how NPL significantly interfere with bank development in emerging countries.

By continuing the trend of examining emergent Asian economies, this study provides additional empirical evidence regarding how undesirable outputs affect bank efficiency outside the United States and European countries. Thirdly, this study contributes to the literature by assessing how regulatory policies and economic events impact bank efficiency in the cross-strait context in regard to deregulation, periods of global financial crises, and bilateral economic cooperation. In this sense, it provides empirical evidence from a longitudinal analysis of the effects of signing the ECFA and the impact of financial reforms on bank efficiency in China and Taiwan from 2008 to 2017. This study also aims to examine how undesirable outputs affect bank efficiency for Taiwan. After implementing a DEA to estimate bank efficiency during the first stage, Tobin's regression model was used to further investigate the determinants of bank efficiency during the second stage.

The purpose of this study is to investigate banks' efficiency in China and Taiwan pre-ECFA and post-ECFA from 2008 to 2017. The rest of the study is organized as follows: section 3 briefly describes the reason for using DEA and the Malmquist index, and it defines the input and output variables. Section 4 reports the two models of bank efficiency in China and Taiwan and compares results of difference models. The final section draws conclusions based on the empirical results and provides suggestions.

2. Background

Between China and Taiwan, finance, economics, trade, and culture were stagnant before the end of the 1980s due to

the politics' interventions in those spheres. The first financial business transaction between Taiwan and China occurred when the Xiamen branch of China Commerce Bank enabled the business of remitting US dollars from China to Taiwan in 1992. In December 2001, the successful World Trade Organization (WTO) accession occurred for China and Taiwan, and the regulators had to open up their financial markets completely for foreign financial institutions. Since that time, especially beginning in 2001, regulators have allowed Taiwanese banks to establish partial offices in China and cultivate business cooperation, supported by bilateral banks to reinforce the permitted scope of financial dealings. In this period (pre-ECFA), Taiwanese banks were only able to collect business information and market surveys, and could not deal with real financial activity.

In line with the basic principles of the WTO and in consideration of the economic conditions of the two parties, the cross-straits neighbors decided to gradually reduce or eliminate barriers to trade and investment for each other, further advance cross-straits trade and investment relations, and establish a cooperation mechanism beneficial to economic prosperity and development for the cross-straits area. In a major development, in June 2010, the governments of China and Taiwan signed the Economic Cooperation Framework Agreement following multiple bilateral negotiations. That same year, China's Banking Regulatory Commission approved the plans of six Taiwanese banks to establish branches in China. By 2016, the number of such banks in the country had more than doubled, from six to thirteen.

Under the ECFA early harvest plan in service relative to banking and other financial service, the cross-strait financial regulator allows counterpart banks entry to the host market. They are sustained to negotiate relatively supporting policies, such as investment protection, agreements on trade in services, and dispute settlement agreements. From the other direction, since 2011 Chinese banks, such as China Merchants Bank and China Construction Bank, have established branches in Taiwan. As another sign of the cross-strait financial cooperation, a bilateral Chinese–Taiwanese regulatory commission met in Taipei in 2011 to discuss the construction of a platform for supervising Taiwanese financial institutions in China and Chinese ones in Taiwan.

3. Methodology

3.1. Data Envelopment Analysis

In this study a non-parametric analytic technique for the measure of bank efficiency is applied. The efficiency measurement of any production function of business is highly, significant for decision-making, further improvement and survival as a whole. As discussed in the literature

review, the highly-recommended tool for efficiency studies is the DEA (Naushad et al. 2020). Specifically, this study adopts DEA, which is a non-statistic model using liner programming. It provides a measure of different decision-making units (hereafter DMUs) operating and performing the same or similar tasks for relative technical efficiency. DEA model main advantage is that it can deal with the case of multiple outputs and inputs as well as factors, which are not controlled by individual management. Besides, this study skip problem like the necessity to determine the functional form or to determine the statistical distribution of the ratios.

That is, the DEA model seeks to determine, which of the N DMUs determine an envelopment surface or efficient frontier. The best-practice production frontier for a sample of firms is constructed through a piecewise linear combination of an actual input-output correspondence set that envelope the input-output correspondence of all firms in the sample (Thanassoulis, 2001). The DEA model produces relative, rather than absolute, measure of efficiency for each DMU under consideration. DEA measures a DMU as efficiency score if it has the best rate of any output to any input and this shows the significance of the outputs-inputs taken under consideration. The classic DEA model assumes that inputs must be minimized and outputs maximized. Seiford and Zhu (2002), however, have developed an alternative approach to treat both desirable and undesirable factors differently in the standard linear BCC DEA model provided by Banker et al. (1984).

Let $y \in R_M^+$ indicate a vector of desirable outputs, $b \in R_J^+$ indicate a vector of undesirable outputs and $x \in R_K^+$ indicate a vector of inputs. This study wants to assess productivity of banks. Each bank has measurable inputs and outputs (x_k, y_k, b_k) , where k is an index of an individual bank. First, define the production possibility set as the set of desirable and undesirable outputs that can be produced from a given level of inputs, which is written as

$$P(x) = \{(y, b): x \text{ can produced}(y, b)\} \quad (1)$$

where $P(x)$ is convex and compact, which requires that only finite outputs should be produced give finite inputs. If output are weakly disposable, i.e., if $(y, b) \in P(x)$ and $0 \leq \theta \leq 1$ then $(\theta y, \theta b) \in P(x)$ and if good and bad outputs are null-joint, i.e., $(y, b) \in P(x)$, $b=0$ implies that $y = 0$. See Shephard (1970) and Shephard and Fare (1974) for details.

Obviously, this study wishes to increase the y and to decrease the b to improve the efficiency. However, in the standard BCC model, both y and b are supposed to increase to improve the efficiency. Following Fare et al. (1989), BCC model into the non-linear programming problem:

$$\begin{aligned} & \max \phi \\ & \text{s.t. } \sum_{k \in K} z_k x_k + s^- = x_{kn}, \quad n = 1, \dots, N. \\ & \sum_{k \in K} z_k y_k - s^+ = \phi y_{km}, \quad m = 1, \dots, M. \\ & \sum_{k \in K} z_k b_k - s^+ = \frac{1}{\phi} b_{kj}, \quad j = 1, \dots, J. \\ & \sum_{k \in K} z_k = 1, \quad z_k \geq 0, \quad k = 1, \dots, K \end{aligned} \quad (2)$$

Second, based upon classification invariance, this study next explains that an alternative to model (2) can be developed to preserve the linearity and convexity in DEA. This study multiply each undesirable output by ‘-1’ and then find a proper translation vector w to let all negative undesirable outputs be positive. Thus, the production possibility set as the set of desirable and undesirable outputs that can be produced from a given level of inputs, which is written as

$$P(x) = \left\{ \theta : \left(\frac{(y, \bar{b})}{\theta} \right) \in P(x) \right\} \quad (3)$$

where the k th column of translated bad output now is $\bar{b}_k = -b_k + w > 0$, and $w = \max\{b_k\} + 1$.

From a methodological point of view, ignoring NPLs is also a major weakness and is likely to result in biased conclusions (Atkinson and Dorfman, 2005). Thus, bank managers want to keep risky assets as low as possible, i.e. minimize undesirable outputs for a given level of inputs. This desired mechanism cannot be properly addressed by traditional DEA models (Fare and Grosskopf, 2004, Seiford and Zhu, 2002). In order to increase the desirable outputs and to decrease the undesirable outputs, using the non-parametric approach $P(x)$ can be formulated as follow:

$$\begin{aligned} & \max \lambda_k \\ & \text{s.t. } \sum_{k \in K} z_k y_{km} \geq \lambda_k y_{km}, \quad m = 1, \dots, M. \\ & \sum_{k \in K} z_k \bar{b}_k \geq \lambda_k \bar{b}_{kj}, \quad j = 1, \dots, J. \\ & \sum_{k \in K} z_k x_{kn} \leq x_{kn}, \quad n = 1, \dots, N. \\ & \sum_{k \in K} z_k = 1, \quad z_k \geq 0, \quad k = 1, \dots, K \end{aligned} \quad (4)$$

where k, m, j and n are indexes of banks, desirable outputs, undesirable outputs and inputs, respectively.

The constrains for the undesirable outputs $b_j, j = 1, \dots, J$ are equality constrains that model the idea that these outputs are not freely disposable. The following theorem ensures that the optimized undesirable output b_j of cannot be negative. Meanwhile free disposability of

desirable outputs y_m , $m = 1, \dots, M$, and inputs x_n , $n = 1, \dots, N$, are allowed by using the inequalities in their respective constrain.

The optimal value λ_k , takes the minimum value of zero when it is not possible to expand the desirable outputs and contract undesirable outputs. This means that bank is efficiency producing at the maximum possible outputs. To assess the productivity of k banks, it solve (4) k times, each for an individual bank. This study will call the optimal value λ_k an efficiency score. A higher value of λ_k indicates a higher level of efficiency, as a results, it can be used to rank the efficiency of banks.

Empirical studies generally apply two approaches when measuring bank outputs and costs. The intermediation approach defines bank as transformers of deposits and purchased funds into loans and other assets. The production approach considers that banks produce accounts of various sizes by processing deposits and loans, incurring capital and labor costs. Previous studies usually depend on the availability of data and the purpose of the study. These approaches differ only in the treatment of banking activity; see Drake et al. (2006) for details. The input-output specification of the present study is based on the intermediation approach suggested by Berger (2009), Seiford and Zhu (1999) Peng et al. (2017) and Liao (2018). Like most such research, this study follows the intermediation approach definition of input-output variables, in which the number of employees, the operating expenses, and the total assets are the input factors. Meanwhile, the two outputs with the basic model are the total loans and the operating revenue, which are commonly used in the literature (Bonin et al., 2005 and Hsiao et al., 2010). Following Assaf et al. (2013), this study will add one output, non-performing loans, as part of the undesirable model. For this study, the primary data source was Taiwan Economic Journal (TEJ). The macroeconomic data sources were National Statistics, ROC (Taiwan) and the National Bureau of Statistics of China. Data sourced from websites: <http://stat.gov.tw> for Taiwan and <http://www.ststs.gov.cn> for China. The unbalanced panel data samples included 46 banks during 2008 to 2017. The total observation included 400 full samples.

3.2. Empirical Regression Design

Following other studies, this study attempts to establish an empirical regression equation. To further investigate the determinants of bank efficiency, a Tobin regression model was implemented to determine whether bank efficiency derived from the pooled sample is related to bank-specific factors, including a set of control variables as well as vectors of country. From there, a Tobin regression model

was constructed for the determinants of bank efficiency. The empirical equation can be written as:

$$EFF_{it} = f(DV_{it}, GDP_{it}, INF_{it}, DV_{it} \times INF_{it}, DV_{it} \times GDP_{it}, X_{it}) \quad (5)$$

where EFF indicates bank efficiency, DV indicates the dummy variable, which equals one if the bank is from China and zero if otherwise. GDP indicates the rate of gross domestic product growth, INF indicates the inflation rate for China and Taiwan, $DV \times GDP$ and $DV \times INF$ indicate the interaction of the two macroeconomic variables with the dummy variables of the two countries. X_{it} indicates the control variables, Including the natural logarithm of bank assets (SIZE), total equity divided by total bank assets (EA), market share of loan activities (MS), risk lever of banks measured by Z-Score (ZS), NPL indicates another risk index measured by non-performing loans to total loans.

Based on Basel risk framework, this study assumed that banks face two major sources of risk: credit risk and operating risk. This study attempts to incorporate these two aspects of risks. Following Partovl and Matousek (2019), this study used non-performing loans as proxies for credit risk. The operating risk was measured by Z-score, as a measure of bank risk-taking. Most studies use the natural logarithm of the Z-score, which is the number of standard deviations that a bank's rate of return on assets has to fall for the bank to become insolvent, such as was found by Demirguc-Kunt and Huizinga (2010) and Tran and Nguyen (2020). In general, Z-score is measured by

$$Z\text{-Score} = \frac{(ROA + EA)}{\sigma(ROA)} \quad (6)$$

where ROA is the mean return on assets, EA is the mean equity to assets ratio, and $\sigma(ROA)$ is the standard deviation of ROA. A higher Z-score indicates higher bank stability than a lower Z-score. Table 1 provides descriptive statistics of the empirical variables.

4. Empirical Results

4.1. Results of the Banks' Efficiency

This section reports the results of an analysis of banks' efficiency using the output-orientated DEA model. As can be seen in Table 2, although the mean overall technical efficiency score is 0.5812, which is similar to those found in previous studies; Yao et al. (2007) found a mean efficiency of 63% in the Chinese banking industry from 1995 to 2001. Yin et al. (2013) have shown the average level of technical efficiency over the period is 0.597 with the profit model. Thus, this

Table 1: Descriptive statistics of variables employed in this study

	mean	Std.
<i>DEA model</i>		
Operating revenue	1,155,469.3	2,467,833.3
Loans	1,558,293.2	2,341,641.6
Non-performance loans	171,564.2	95,248.7
Employees	49,542	111,574
Total assets	2,956,646.4	4,536,312.2
Operating expense	40,999.9	68,765.8
<i>Regression model</i>		
SIZE	21.0164	1.266
EA	6.54(%)	0.0155
MS	5.597(%)	0.0505
ZS	0.4779	0.891
NPL	1.16(%)	0.0107
GDP	5.2349(%)	3.6793
INF	1.761(%)	1.6682

Note: The unbalanced panel data samples included 46 banks (Including Chinese banks and Taiwanese banks) during 2008 to 2017. The total observation included 400 full samples. Unit: million

Table 2: Results of banks efficiency with basic model

	Average annual change		
	OTE	PTE	SE
2008	0.41	0.774	0.476
2009	0.515	0.758	0.603
2010	0.432	0.799	0.477
2011	0.418	0.777	0.472
2012	0.575	0.828	0.612
2013	0.652	0.742	0.783
2014	0.617	0.754	0.73
2015	0.689	0.797	0.798
2016	0.701	0.803	0.848
2017	0.74	0.82	0.868
mean	0.5812	0.7864	0.6747

Notes: The “mean” indicate the average the entire sample value. The banks efficiency score that range from 0 to1. OTE=Overall technological efficiency, PTE=Pure technical efficiency, SE=Scale efficiency.

result suggests that China and Taiwan banks’ efficiency might have not improved after WTO accession (before 2010). On the other hand, this study’s finding is that overall technical efficiency increased from 2012 to 2017, reaching 0.575, 0.652, 0.617, 0.689, 0.701 and 0.74, respectively. This result implies that bank efficiency has improved after the signing of the cross-straits cooperation agreement (ECFA).

The mean overall technical efficiency, pure technical efficiency, and scale efficiency scores were 0.5749, 0.7852, and 0.6667, respectively, which suggests that these banks improved their efficiency by 43%, 21.5%, and 33.3%, respectively. This result indicates that nearly 40% of the banks’ costs are wasted according to the best-practice frontier when facing the same output within samples. Regarding

bank efficiency sources, the mean pure technical efficiency is higher than the scale efficiency, which indicates that scale inefficiency is a major source of bank inefficiency. This result indicates that the inefficiency of banks may be attributed to a problem in reaching optimal returns to scale rather than underutilization of input or the incorrect selection of input combinations. One possible reason is that the operating scale of the majority of Taiwanese banks is significantly smaller than that of Chinese banks; some Chinese banks are ranked among the Top 500 enterprises in the world. Thus, Taiwanese regulators allowed banks to enter the Chinese financial market to increase operating activities as a measure to improve efficiency.

4.2. Results of the Banks' Efficiency with Undesirable Outputs

This section reports the banks' efficiency with an undesirable outputs model. As can be seen in Table 3, this finds that the mean overall technical efficiency is 0.6974

and the banks have an average waste of 30.26% per year, implying that the gap between banks' efficiency is large no matter which model is used and an uneven efficiency problem exists in the banks of both China and Taiwan. I observe an upward trend in efficiency score since 2011 for both models and lower bank efficiency scores during the global financial crisis of 2008–2009. Two possible reasons can be given for this result. First, the permission from the regulator for entry of foreign banks into China has created unprecedented competitive pressure on domestic banks after WTO accession. This implies that domestic banks must improve their efficiency in order to succeed or even survive. Second, the Taiwan regulator initiated deregulation for banks in the early 1990s, but the majority of Taiwanese banks keep a low efficiency due to their lower scale of operation. One benefit from ECFA has been that Taiwanese banks can enter the Chinese market, thus, expanding their business activities and improving their scale.

As can be seen in Table 4, test results show that the efficiency score estimated with undesirable outputs was

Table 3: Results of banks efficiency with undesirable outputs

	Average annual change		
	OTE	PTE	SE
2008	0.753	0.922	0.803
2009	0.582	0.869	0.622
2010	0.703	0.91	0.746
2011	0.694	0.822	0.795
2012	0.716	0.928	0.749
2013	0.765	0.912	0.816
2014	0.68	0.903	0.704
2015	0.792	0.888	0.877
2016	0.594	0.862	0.634
2017	0.709	0.882	0.763
mean	0.6974	0.889	0.7494

Notes: The "mean" indicate the average the entire sample value. The banks efficiency score that range from 0 to 1. OTE=Overall technological efficiency, PTE=Pure technical efficiency, SE=Scale efficiency.

Table 4: Results of the difference between basic and undesirable models

	Efficiency Score			
	Basic model	Undesirable model	T value	F value
OTE	0.5812	0.6974	-4.415***	19.491***
PTE	0.7864	0.889	-5.655***	31.984***
SE	0.6747	0.7494	-3.211***	10.313***

Notes: The table reports coefficients t-statistics in parentheses. ***, ** and * indicate 1, 5, and 10% significant levels, respectively. T value is measured by independent sample T test; F value is measured by one way ANOVA test.

slightly higher than that without undesirable outputs. This result is, thus, consistent with Assaf et al. (2013), who found that excluding crediting banks from their production of bad outputs resulted in misspecification, which appears as an underestimation of both efficiency and productivity change. The result shows that the efficiency assessment of the banks when their undesirable outputs are ignored is generally different and may seriously distort efficiency results. This result agrees with my expectation that not regard banks for their production of bad outputs results in misspecification, which shows up as underestimation of efficiency.

4.3. Results Compared Between Different Models

This study compared bank efficiency in three ways. First, the study conducted a test to verify whether Chinese and Taiwanese banks' efficiency was significantly different. Second, this study compared bank efficiency over two periods: Global financial crisis from 2008 to 2010 (GFR period or pre-ECFA) and after ECFA from 2011 to 2017 (post-ECFA). Third, the five largest commercial banks are still dominating the banking industry in China, similar to the condition of banks in Taiwan. Thus, this study conducted a test to verify whether state-owned banks are more efficient than privately owned banks.

As can be seen in Table 5, the mean overall technical efficiency scores using the basic model and the undesirable outputs model were 0.8756 and 0.8894 in China, and 0.3511 and 0.5525 in Taiwan, respectively. These test results show that the Chinese banks' efficiency was significantly higher than the efficiency of the Taiwanese banks. Two possible reasons could explain that outcome. First, China's economy is currently growing at the highest rate in the world, with a high average economic growth rate, the largest amount of foreign indirect investment, and international financial institutions established in branches or subsidiaries there. Second, Das and Ghosh (2009) indicated that the listed banks' efficiency was higher than non-listed banks in India. This study data included only the listed banks in China, and included listed and non-listed banks in the Taiwanese sample. Thus, this result may not be that surprising due to limited data that are available to estimate China banks' efficiency. This study data source is the *Taiwan Economic Journal*; more complete information, including financial annual reports and balance sheet data, is not available. Further research to resolve this problem could be useful.

As can be seen in Table 5, these results show that the global financial crisis period was lower than the post-ECFA period, which is consistent with Choudhry and Jayasekera (2012) and Belanes et al. (2015). This result shows the subprime mortgage crisis period decline in bank efficiency and then an upward trend from 2011. However, mean overall

technical efficiency has still existed, as practically 32% of bank costs are wasted according to best-practice frontier.

As can be seen in Table 5, the finding that the mean overall technical efficiency of state-owned banks is significantly higher than that of private banks implies that ownership structure plays a key role in banks' efficiency. Bonin et al. (2005) illustrated that state-owned banks continue to enjoy the advantages of regulator policies in emerging countries. It indicates that state-owned banks experience greater efficiency than non-state-owned banks, which in turn implies that bureaucratic power still plays an important role in bank efficiency for emerging countries, as the regulator often intervenes in the financial market and in bank operating management. Liao (2018) suggested that the regulator must improve the imperfect competitive market and avoid inappropriate interventions into market operations.

4.4. What Are Determinants of Bank Efficiency in Cross-Strait?

This section explains the determinants of bank efficiency estimates derived from the DEA model using the basic DEA model and the undesirable outputs DEA model. As can be seen in Table 6, the coefficient of SIZE is positive and significant, implying that managers could improve their bank's efficiency by increasing asset size. This result is consistent with Kwan (2006) and Liao (2018). The coefficient of EA was positive and significant. Commercial banks need to maintain a minimum capital as per instructions of the central bank, but banks would still hold the capital even in an unregulated economy because the markets force them to do so. This capital is kept as a cushion to absorb unforeseen losses to some extent (Sarwar et al. 2020). The equity-to-assets ratio as a proxy of the external corporate governance indicator implies that equity stakes could put pressure on management to reduce efficiency shortfalls (Liao, 2018). The coefficient of MS is negative and significant, implying that larger market power of loan activity would decrease banks' efficiency, and bank managers have a lack of ambition concerning loan quality.

In general, higher operation uncertainty is seen when banks have a higher profitability volatility, which indicates that banks with higher profitability volatility should be more inefficient than other banks. The coefficient of ZS is insignificant in all columns, implying that banks still experience high efficiency even if they have high operating uncertainty. One possible reason for this result is that the Chinese regulator has been injecting capital into the banks for free in the last two decades. If banks hold a higher level of capital, it could increase banks' efficiency; thus, China's regulator has aggressively injected capital into the banks to counterbalance the risk. The coefficient of NPL is negative and significant, implying that holding a higher volume of NPL decreases banks' efficiency because they deteriorate the quality of assets in a bank, and this result is consistent with Partovi and Matousek (2019).

Table 5: Results of the difference between bank efficiency of China and Taiwan

	Efficiency Score			
Basic model	CN	TW	T value	F value
OTE	0.8756	0.3511	17.689***	280.947***
PTE	0.9507	0.6625	12.241***	120.858***
SE	0.9097	0.4973	15.208***	200.201***
Undesirable	CN	TW		
OTE	0.8894	0.5525	11.735***	122.541***
PTE	0.9711	0.827	8.071***	52.311***
SE	0.9074	0.6302	10.733***	102.948***
Basic model	GFR	Post-ECFA		
OTE	0.3385	0.6768	8.641***	68.479***
PTE	0.6369	0.8453	6.086***	44.589***
SE	0.4939	0.7458	6.628***	45.821***
Undesirable				
OTE	0.5179	0.7681	6.814***	47.845***
PTE	0.8133	0.9188	4.116***	21.612***
SE	0.6040	0.8067	6.108***	29.768***
Basic model	Stated-owned banks	Non-stated owned bank		
OTE	0.728	0.5198	5.289***	24.084***
PTE	0.9063	0.7363	6.629***	29.399***
SE	0.7769	0.6319	4.057***	14.493***
Undesirable				
OTE	0.5179	0.7681	6.814***	47.845***
PTE	0.8133	0.9188	4.116***	21.612***
SE	0.6040	0.8067	6.108***	29.768***

Notes: The table reports coefficients t-statistics in parentheses. ***, ** and * indicate 1, 5, and 10% significant levels, respectively. T value is measured by independent sample T test; F value is measured by one-way ANOVA test, CN is China and TW is Taiwan.

The coefficient of DV was positive and significant with the basic model, which indicates that Chinese banks experience greater efficiency than Taiwanese banks. The sign is insignificant using the undesirable outputs model, which in turn implies that undesired outputs play an important role in the efficiency of cross-strait banks. One possible reason for this difference is that the volume of NPL is still higher, especially for the state-owned commercial banks in China, due to the fact the regulator still has influence on or control of the banks' operation, especially the credit allocation (Tan and Floros, 2013).

The coefficient of GDP and INF was significantly negative, which was against the expectation of my study.

This implies that countries with more sustainable economic growth to tend have a decline in banks' efficiency. On the other hand, the Interaction term coefficient of DGDP was positive and significant, implying that higher GDP growth would increase banks' efficiency in China, but not in Taiwan. One possible reason for this result was the regulator twice executed financial reform and reconstruction in Taiwan after 2000. Hsiao et al. (2010) showed that the financial reconstruction period lowered banks' efficiency. Thus, economic growth benefits have not significantly impacted banks' efficiency.

Table 6: Regression Results of determinants of banks efficiency

	Model A		Model B		
	OLS	TB	OLS	TB	VIF
<i>Con.</i>	-3.525 (-8.635)***	-4.928 (-8.657)***	-2.51 (-5.71)***	-2.937 (-5.952)***	
<i>SIZE</i>	0.181 (9.106)***	0.242 (8.88)***	0.143 (6.676)***	0.161 (6.746)***	3.78
<i>EA</i>	4.499 (5.166)***	6.321 (5.073)***	2.428 (2.578)**	3.009 (2.775)***	1.096
<i>MS</i>	-1.613 (-3.482)***	-2.327 (-4.038)***	-1.222 (-2.466)**	-1.414 (-2.662)***	3.262
<i>ZS</i>	0.027 (1.547)	0.03 (1.366)	0.007 (0.389)	0.05 (0.217)	1.411
<i>NPL</i>	-1.078 (-0.742)	-4.098 (-1.983)*			1.443
<i>DV</i>	0.18 (2.379)**	0.18 (1.945)*	0.12 (1.47)	0.1246 (1.414)	8.383
<i>GDP</i>	-0.12 (-2.188)**	-0.024 (-2.483)**	-0.002 (-0.416)	-0.04 (-0.531)	2.32
<i>INF</i>	-0.14 (-1.229)	-0.035 (-1.681)*	0.019 (1.592)	0.024 (1.722)*	2.21
<i>DGDP</i>	0.224 (2.233)**	0.041 (2.794)**	0.01 (0.854)	0.012 (0.96)	9.656
<i>DINF</i>	0.022 (1.11)	0.048 (1.703)*	0.004 (0.177)	0.001 (0.46)	4.307
<i>R</i> ²	0..587		0.352		
Log likelihood function		30.58		-40.78	

Notes: The variance inflation factor (VIF) was implemented to test whether the collinearity problem is significant. All variables of VIF were less than 10, which imply that there were no collinearity problems in the regression analysis. Model A dependent variable is overall technical efficiency with basic model, Model B dependent variable is overall technical efficiency with undesirable model. OLS=ordinary least square, TB=Tobit regression. The table reports coefficients t-statistics in parentheses. ***, ** and * indicate 1, 5, and 10% significant levels, respectively.

5. Conclusions

The purpose of this study was to investigate whether signing the ECFA affected efficiency in cross-strait (China and Taiwan) banks. The finding was that overall technical efficiency increased from 2012 to 2017, reaching 0.575, 0.652, 0.617, 0.689, 0.701 and 0.74, respectively. This result implies bank efficiency did indeed improve after China and Taiwan signed the ECFA cooperation agreement. Further analysis shows that Chinese banks have experienced a greater efficiency effect in the study period. Two possible reasons were suggested for this result. First, China's economy is currently growing at the highest rate in the world, with a high average economic growth rate and the

largest amount of foreign indirect investment. Second, most international financial institutions have established branches or subsidiaries there. The entry of foreign banks will often be accompanied by a technology transfer and a know-how spillover effect for domestic banks. Foreign banks want to maintain their international experience advantage in order to compete with domestic banks in emerging markets. Thus, the entry of foreign banks into local financial markets certainly improves the technology of banks in the host country. The results show banks' efficiency using the undesirable outputs model, indicating that the efficiency score estimated with undesirable outputs was higher than that without undesirable outputs. This implies that excluding crediting banks from

their production of bad outputs resulted in misspecification, which appears as an underestimation of banks' efficiency.

This finding provides two directions for policy makers to target for preventing banks from improving banks' efficiency. First, this finding that the efficiency of state-owned banks is significantly higher than that of private banks implies that the ownership structure plays a key role in banks' efficiency. Bonin et al. (2005) argued that state-owned banks continue to enjoy the advantages of regulator policies in emerging countries, which in turn implies that bureaucratic power still plays an important role in bank efficiency for such countries, even for banks with larger operating uncertainty risk, as the regulator often over-intervenes in the banks' management and persistently protects and regulates its rivals (Liao, 2018). Second, ECFA is only a framework agreement. Early harvest plans in the services already have had a preliminary effect for improved bank efficiency. This suggests that cross-strait sustained negotiations to consummate an agreement on trade in the services will be a very important mission in the future.

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