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First Financial Restructuring and Operating Efficiency: Evidence from Taiwan Commercial Banks

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Abstract

This paper investigates the effect of the "First Financial Restructuring" (FFR) on the operating efficiency of commercial banks in Taiwan. Applying data envelopment analysis (DEA) to operations data for 40 commercial banks over the five year period 2000-2004, we find that while the banks had lower operating efficiency on average during the reform period (2002-2003) compared to the pre-reform period (2000-2001), improved operating efficiency was reflected in the post-reform period (2004). Our results remain unchanged even after controlling for the nonperforming loan ratio, capital adequacy ratio, bank ownership and size. Overall, our results indicate that the improved efficiency in the post-reform period was possibly due to the reduction of nonperforming loans rather than the boosting of capital adequacy in the reform period.

Keywords: First Financial Restructuring (FFR); Commercial banks; Taiwan; Operating efficiency; Data envelopment analysis (DEA)

1. Introduction

The banking systems of many developing economies have exhibited poor performance, perhaps due, in part, to excessive government regulations. To address this problem, various financial liberalizations, reforms and restructuring programs have been implemented in an effort to foster banking efficiency and a better allocation of resources (Isik and Hassan, 2003).[1] The impact of these measures on bank efficiency has been widely studied with approximately 95% of this research focusing on banks of industrialized countries, especially the US (e.g., Berger and Mester, 2003; Sturm and Williams, 2004). However, only a limited number of these studies have examined the impact of deregulation and liberalization programs on developing economies (e.g., Kwan, 2003; Williams and Nguyen, 2005; see Berger and Humphrey, 1997, for a review). Overall, the effects of these regulatory efforts have been mixed (e.g., Kumbhakar and Sarkar, 2003; Altunbas et al., 2000; Yildirim and Philippatos, 2007).

The current study addresses the scant research on developing economies by examining whether a Taiwan government regulatory banking reform – the so-called "First Financial Restructuring" (FFR hereafter) – accomplished its mission to improve the operating efficiency of the banking sector. Taiwan banking had been severely impacted by various political and environmental factors including threats from the military exercises of Mainland China conducted in 1995; the East Asian financial crisis beginning in Thailand in 1997; and local financial scandal tornados derived from massive nonperforming loans in 1998. In an effort to avert a possible financial crisis and to establish a sound banking system, the regulatory authorities issued various

[1] A better resource allocation will benefit society by leading to greater and more appropriate innovations, improved profitability, greater amounts of funds intermediated, better prices and service quality for consumers, and greater safety and soundness in the financial system.

reforms, regulations, and restructuring programs, including the FFR[2] (Konishi and Yasuda, 2004). This reform required the nonperforming loan ratio of financial institutions to be below 5% and the capital adequacy ratio to be at least 8% by 2003 (i.e., within 2 years of the regulation being passed by Congress in 2002). Prior research has emphasized the importance of these ratios to accounting and regulatory consequences (e.g., Anandarajan et al., 2005; Moyer, 1990) and documented their relation to efficiency (e.g., Niswander and Swanson, 2000; Das and Ghosh 2006).

We use data envelopment analysis (DEA), a non-parametric approach, to analyze the extent of change in operating efficiency in the Taiwan banking sector following FFR. We examine banking data for the five year period 2000-2004 for a sample of 40 commercial banks in Taiwan. Our results indicate that banks had lower operating efficiency during the FFR reform period (2002-2003) compared to the pre-reform period (2000-2001), but had higher operating efficiency in the post-reform period (2004). Further, our results indicate that while banks with a higher capital adequacy ratio had higher operating efficiency, banks with a higher nonperforming loan ratio during the reform period had lower operating efficiency. These results suggest that the FFR led to improved operating efficiency in the banking sector in the post-reform period, possibly due to the reduction of nonperforming loans rather than the boosting of capital adequacy during the FFR reform period.

Our study contributes to the literature in at least three ways. First, our study provides evidence of the efficiency change of the banking industry in Taiwan in response to the FFR. The ability of banks to allocate funds as efficiently as possible to finance productive investment and consumption expenditures is crucial in producing a high and sustainable rate of economic growth.

[2] Measures adopted by the Taiwan government include: deregulation of interest rates and foreign exchange rates restrictions, liberalization of the establishment of new banks and foreign entry, enlargement of the business scope of financial institutions, and internationalization of financial market operations.

Evaluating how the FFR affects efficiency will provide insight for bank management seeking to improve operating performance and policymakers considering financial reforms. Second, our study provides additional empirical evidence on the impact of reforms on bank efficiency outside the United States. While financial reform and liberalization policies may be effective for developed economies, such policies may not bring optimal outcomes for developing countries where markets and institutional structures are different from those of developed countries. Therefore, it is important to examine the effects of government regulations on bank efficiency in developing countries (Isik and Hassan, 2003). Third, the current study provides evidence of the impact of reforms before, during and after the financial restructuring. Most prior studies examining the effects of reforms investigate the efficiency after or during the deregulation period without covering the period before the liberalization or deregulation programs (Denizer et al., 2007). Extending the evaluation to before and after deregulation may be important in determining future bank performance (Berger and Humphrey, 1997) and the real impact of liberalization programs on efficiency (Harker and Zenios, 2000).

The remainder of this paper is organized as follows. In section 2, we briefly review studies related to financial reforms of banking and discuss the impact of nonperforming loans and capital adequacy on operating efficiency to motivate our research hypotheses. In section 3, we describe our research methodology including data and sample as well as the DEA model used to estimate bank operating efficiency. In section 4, we present and discuss our empirical results. Finally, conclusions and implications of our findings are discussed and directions for future research are offered in section 5.

2. Literature review and hypotheses development

2.1 The impact of financial reform on banking operating efficiency

Efficiency represents the ability of management to control costs and use resources available to produce output. Although a primary goal of deregulation is to improve efficiency, numerous studies examining the impact of financial reforms on banking performance and efficiency provide mixed results.[3] Some studies suggest that financial reform improves efficiency. For instance, Norwegian and Turkish banks experienced improved efficiency after deregulation (Berg et al., 1992; Zaim, 1995, respectively). In addition, Kumbhakar and Sarkar (2003) analyzed the relationship between deregulation and performance improvement using data from the Indian banking industry over a 12-year period from 1985 to 1996. They found that the performance of private, but not public, banks improved in response to deregulation measures. Recently, Das and Ghosh (2006) used DEA to evaluate the efficiency of Indian commercial banks during the post reform period of 1992-2002. They found that medium-sized public banks performed reasonably well and efficiency improved.

In contrast, other studies find that financial reform has no efficiency effect or leads to a decline in operating efficiency. For instance, banking efficiency in the US was relatively unchanged by deregulation (Bauer et al., 1993; Elyasiani and Mehdian, 1995). Halkos and Salamouris (2004) employed DEA to examine the performance of the Greek banking sector during 1997-1999, a period of various financial reforms.[4] They found a decrease in average efficiency level in 1988, followed by a significant increase and maximum attained performance in 1999. Similarly, Fukuyama and Weber (2002) found that the efficiency of Japanese banks during 1992-1996 declined and Park and Weber (2006) found declines in efficiency for Korean

[3] See Berger and Humphrey (1997) for a discussion of the possible explanations for this mixed evidence and Berger (2004) for a detailed review of banking efficiency studies.

[4] Such reforms included the liberalization of interest rate determination; the abolition of various credit rules; the free movement of capital; and the increased competition from banks of the European Union.

banks during 1992-2002.

2.2 The impact of the FFR on banking operating efficiency

In this study, we examine the operating efficiency of the banking sector during the pre-reform (2000-2001), reform (2002-2003), and post-reform (2004) periods of the FFR in Taiwan. Recall that this reform required banks to have a minimum capital adequacy ratio of 8% and a maximum nonperforming loan ratio of 5% by the end of 2003.[5] If a bank complies with these two criteria of the FFR, then it enjoys several benefits including improved bank efficiency through entry deregulation, branch de-licensing, and deregulation of interest rates. Penalties would be imposed on banks not complying with these requirements. For instance, by the end of 2003, if the nonperforming loan ratio was over 5%, the addition of new domestic and international branches would be prohibited, as well as applications for converting a general branch to a combo branch. If the ratio is over 15%, the banks would be required to simplify their branches, which would decrease the market share, increase operating costs, and lower operating profit.

2.2.1 Nonperforming loans and banking operating efficiency

According to Berger and DeYoung (1997), in order to reduce nonperforming loans, banks incur more costs associated with performing additional operating activities including: (a) additional monitoring of outstanding accounts receivable, delinquent borrowers and the value of their collateral; (b) analyzing and negotiating possible workout arrangements; (c) seizing, maintaining, and eventually disposing of collateral; (d) defending the bank's safety and

[5] In Taiwan, the principal government agencies responsible for the supervision of financial institutions are the Central Bank of China, the Ministry of Finance, and the Central Deposit Insurance Corporation. These three bank regulators use the CAMELS rating system, which consists of six categories – Capital adequacy, Asset quality, Management, Earnings, Liquidity, and Sensitivity to market risk – to evaluate the banks in Taiwan (Kao and Liu, 2004). This system relies on various financial ratios obtained from periodic reports of the entities under their jurisdiction. Nonperforming loan and capital adequacy ratios are two such performance indicators relevant to banking performance.

soundness record to bank supervisors and market participants; (e) taking additional precautions to preserve the high quality of loans; (f) writing-off nonperforming loans to bad debt expense;[6] and (g) managing financial risk. The increase in operating expenses from reducing bad debt will offset revenues and negatively impact banking operating efficiency. Thus, nonperforming loans may lead to lower efficiency because of the increased expenses associated with the managing nonperforming loans (i.e., monitoring, negotiating workout arrangements, seizing and disposing of collateral, and diverting senior management focus).

Consistent with this notion, prior research has documented a negative relation between nonperforming loans and efficiency. For instance, Berger and DeYoung (1997) found that prior to failure, failing banks have a large proportion of nonperforming loans, suggesting weak balance sheet conditions, poor quality of loan assets, and bank fragility. Using bank data from 1996 to 2001, Das (2002) found that higher nonperforming loans lead to lower efficiency. In addition, Das and Ghosh (2006) found that increases in nonperforming loans tend to be followed by decreases in efficiency, suggesting that high levels of sticky loans cause banks to increase spending on monitoring, administering and/or selling off these loans, and possibly become more diligent in administering the portion of their existing loan portfolio that is currently performing. Furthermore, Berger and Mester (2003) found that lower nonperforming loans improved operating efficiency over time in that the costs required to deal with problem loans decreased as the amount of outstanding loans declined. Finally, examining Japanese commercial banks between 1993 and 1996, Altunbas, Liu, Molyneux, and Seth (2000) found that the level of nonperforming loans is positively related to bank inefficiency.

2.2.2 Capital adequacy and banking operating efficiency

[6] According to the Ministry of Finance, write-offs of bad debts were quite high, totaling approximately $974 billion New Taiwan Dollars between 2000 and 2003.

Regarding the capital adequacy requirement, an important aspect of efficiency measurement is the treatment of financial capital. A bank's insolvency risk depends on its financial capital available to absorb portfolio losses and risks. Insolvency risk affects bank costs and profits via the risk premium the bank must pay for uninsured debt, and through the intensity of risk management activities the bank undertakes. For this reason, the financial capital of the bank should be considered when studying changes in efficiency.

The FFR imposed a minimum level of 8% capital adequacy in an effort to stabilize the financial system (Rime, 2001) and to prevent losses (Barth, Caprio and Levine, 2004). The increased emphasis on capital adequacy necessitates changes in the internal functioning of banks, especially in the systems of credit evaluation, risk assessment and management and the quality of human resources, internal control, and corporate governance. Such changes are expected to lead to financial soundness that reduces uncertainties and systemic risk, thereby contributing to improved efficiency. With adequate capital, a bank can pursue profitable opportunities, take intelligent risks, or expand operations. Without adequate capital, banks are constrained to hold large amounts of less risky government securities instead of making potentially more profitable commercial loans and are less able to make desirable investments that can enhance their efficiency. Thus, capital adequacy should have a positive impact on efficiency.

Supporting the rationale for the capital adequacy requirement, Das and Ghosh (2006) documented a positive relationship between banking efficiency and capital adequacy. This results is consistent with the notion that well-capitalized banks are perceived to be relatively safe and have better credit risk management practices, which in turn lowers their cost of borrowing, leading to enhanced efficiency. In addition, Niswander and Swanson (2000) found that banks with substandard or marginal capital adequacy ratios have higher operating costs.

Failure to comply with this capital adequacy requirement of the FFR may result in costly penalties, which may impair efficiency. Specifically, for banks with substandard or marginal capital ratios, regulators can impose costly restrictions including disapproving the establishment of a new branch, merger, project or change in ownership or control and requiring changes to financial statement data or higher minimum capital requirements than other banks (Code of Federal Regulations, 1990, paras. 3.10, 325.3, and 325.4). In addition, banks that are close to their capital constraints come under increased regulatory scrutiny (Thomson, 1991), thereby reducing bank managers' flexibility in using accounting or financing discretion, since available options would then be influenced by the preferences of auditors and regulators.

2.3 Research hypotheses

Given the response to the nonperforming loan requirement of the FFR, we hypothesize that operating efficiency during the reform period (2002-2003) of the FFR will be significantly worse than the pre-reform period (2000-2001). However, in the post-reform period (2004), we argue that with the reduction of bad debts resulting from compliance with the nonperforming loan requirement of the FFR, the bank's asset quality will improve and financial risk will decrease. In addition, as discussed above, prior research has documented a positive relation between the capital adequacy ratio and operating efficiency. Given these two effects, we hypothesize that bank operating efficiency will ultimately improve in the post-reform period compared to reform period. Based on the above discussion, we state our two research hypotheses (all in alternate forms) as follows:

H_1: Bank operating efficiency drops during the reform period of the FFR.

H_2: Bank operating efficiency improves in the post-reform period compared to the reform period of the FFR.

3. Methodology

3.1 Data and sample

The sample of commercial banks that is included in this study is derived from the Taiwan Economic Journal (TEJ) database, the Central Bank of Taiwan, the Taiwanese Economic and Regulation Commission, and related resources. We began with an original sample of 52 banks but eliminated four due to exceptional business types, six due to incomplete data, and two due to merger and acquisition depletion banks. Our final sample consists of 40 commercial banks In Taiwan. Our research period was from 2000 to 2004, including two years before and one year after the FFR program of 2002-2003.[7]

3.2 Data Envelopment Analysis and its test statistics

Performance evaluation and benchmarking have become important continuous assessment and improvement tools for banks in a business environment facing global competition (Cook et al., 2004). Contrary to the incompleteness of a single performance evaluation measure, benchmarking models integrate multiple performance measures. One such model is Data Envelopment Analysis (DEA), a linear programming technique introduced by Charnes et al. (1978) and extended by Banker et al. (1984). DEA has been proven to be an effective tool for evaluating the relative efficiency of peer decision making units (DMUs) when multiple performance measures are present (Banker et al., 1989; Mensah and Li, 1993; Sherman and Zhu, 2005). In addition, it has been used to evaluate banking operating efficiency in response to financial reform (Cook et al., 2004; Das and Ghosh, 2006; Park and Weber, 2006).

[7] We examine only one year (2004) after the FFR because the second phase of the reform began in 2005 and would therefore confound our results. The purpose of this second phase is to promote consolidations by revising outdated regulations to be consistent with international norms, implementing supervisory measures to encourage well-performing financial institutions, and offering incentives for consolidation (Executive Yuan, 2006).

Efficiency can be measured as the minimal consumption of inputs for a given level of output or the maximal augmentation of outputs for a given level of inputs. In general, banks anticipate demand and invest in inputs necessary to support the expected level of demand. Since it is hard for them to adjust input levels once they are committed, we adopt an output-based efficiency measure by assuming that banks maximize outputs given the available inputs. This output-based approach measures how much output can be generated from a given level of inputs (Chang et al., 2004).

The output-oriented efficiency measures is the reciprocal of the inefficiency measure θ_j ,which can be estimated using the following DEA model:

$$\theta_j = Max\theta \tag{1.0}$$

$$\text{s.t. } X_{ij} \geq \sum_{j=1}^{N} \lambda_j X_{ij}, i = 1,...,I \tag{1.1}$$

$$\theta Y_{rj} \leq \sum_{j=1}^{N} \lambda_j Y_{rj}, r = 1,...,R \tag{1.2}$$

$$\sum_{j=1}^{N} \lambda_j = 1 \tag{1.3}$$

$$\lambda_j \geq 0 \tag{1.4}$$

where j is the bank being evaluated, θ_j is the estimated inefficiency for bank j, X_{ij} is input *i* for bank $_j$, Y_{rj} is output *r* for bank $_j$, and λ is the weight placed on banks. Model (1) is constructed under the assumption of variable returns to scale and referred to as the BCC model of DEA (Banker et al., 1984). If a constant return to scale is maintained instead, equation (1.3) is

removed and the resulting model is labeled as the CCR model of DEA (Charnes et al., 1979).

Since the inefficiency θ_j is a consistent estimator (Banker, 1993), we can employ the following two DEA-based test statistics that we describe below to test for the effect of FFR on the operating efficiency of commercial banks in Taiwan.

If θ_j is assumed to be exponentially distributed, then to test the null hypothesis (that FFR has no effect on the operating efficiency of commercial banks) against the alternate hypothesis (that FFR has a negative effect on the operating efficiency of commercial banks), we can employ the test statistic given by

$$T_{exp} = [\sum_{j \in N1} (\theta_j - 1) / N1] / [\sum_{j \in N2} (\theta_j - 1) / N2] \quad (2)$$

which is evaluated by the F-distribution with (*2N1*,*2N2*) degrees of freedom, where *N1* and *N2* are the number of sample commercial banks in the periods before and during 2002-2003 (the period in which the FFR was implemented), respectively.

If the θ_j is assumed to be half-normally distributed for commercial banks, then we can test the null hypothesis against the alternate hypothesis, described above, by employing the test statistic given by

$$T_{hn} = [\sum_{j \in N1} (\theta_j - 1)^2 / N1] / [\sum_{j \in N2} (\theta_j - 1)^2 / N2] \quad (3)$$

which is evaluated by the F-distribution with (*N1*, *N2*) degrees of freedom.

In addition to the two DEA-based statistical tests described above, we also employ three

conventional parametric based tests: (1) the Welch test; (2) the Mann-Whitney test; and (3) the Kolmogorov-Sminrov test to test for the effect of FFR on the operating efficiency of commercial banks in Taiwan.

3.3 Selection of input and output variables

Identifying appropriate inputs and outputs is crucial for the assessment of operating efficiency. Prior banking efficiency studies have employed two different approaches in selecting inputs and outputs: the production approach and the intermediation approach. The production approach emphasizes operational activity and primarily views banks as providers of services to customers. Under this approach, the inputs usually include physical variables such as labor, materials, space, information systems, and branches. The output represents the services provided to customers and are best measured by the number and type of transactions and documents processed or specialized services provided over a given time period (Das and Ghosh, 2006). In contrast, the intermediation approach primarily views banks as financial intermediaries between savers and investors that purchase inputs to generate earning assets (Sealy and Lindley, 1977). Under this approach, both operating and interest expenses are considered as inputs, whereas loans and other major assets are counted as outputs (Drake and Hall, 2003; Isik and Hassan, 2003; Kao and Liu, 2004; Sturm and Williams, 2004; Das and Ghosh, 2006; Havrylchyk, 2006; Park and Weber, 2006). The intermediation approach is preferable since it normally includes interest expense, a large proportion of any bank's total costs (Elyasiani and Mehdian, 1990; Berger and Humphrey, 1991).

According to the Taiwan Banking Law, the role of commercial banks of Taiwan is primarily to mediate funds between depositors and borrowers whose main business is to borrow funds from depositors to lend to others (Kao and Liu, 2004). Given this and the above

mentioned advantages of the intermediation approach, we adopt the intermediation approach in this study. Specifically, following Sturm and Williams (2004), Das and Ghosh (2006), and Park and Weber (2006), we choose two outputs and two inputs for our estimation of banking efficiency. The two inputs we consider are interest expenses and non-interest expenses, while the two outputs we choose consist of interest revenue and non-interest revenue. Interest expenses include expenses for deposits and other borrowed money. Non-interest expenses include service charges and commissions, expenses of general management affairs, salaries, and other expenses. The interest revenue includes interest on loans, income from government bonds and corporate bonds. Non-interest revenue includes services charges on loans and transactions, income from renting and fiduciary activities, commissions, and other operating income.

4. Results and discussions

4.1. Descriptive statistics

Table 1 provides descriptive statistics for bank inputs, outputs, and the FFR policy variables for the five year period from 2000 to 2004. Due to the lower interest rate, the interest expense and revenue of 2002-2004 were substantially lower than those of 2000 and 2001. The monetary values are in New Taiwan (NT) dollars, where 1 US dollar is approximately equal to 33 NT dollars. In 2002, the first year of the FFR, the mean (median) of the non-interest operating expenses (excluding the interest expenses) dramatically increased to $14,323.1 ($8,067.5) million NT dollars which was 21.4% higher than the five year average of $11,255.9 million NT dollars. This appears to result from compliance with the restructuring policy that required bad debt write-offs. Meanwhile, the 2002 mean of the non-interest revenue decreased

24.38% compared to the five year average.

[Insert Table 1]

In Table 1 Panel C, the mean of the nonperforming loan ratio was 8.22% in 2001 and decreased steadily to 3.89% in 2004. The mean of the nonperforming loan ratio for each year was higher than the median. Declining during the four-year period, the means of the nonperforming loan ratio are 8.22%; 7.01%; 5.62%; and 3.89% for 2001; 2002; 2003; and 2004, respectively. Also, decreasing during the four-year period, the medians of the nonperforming loan ratio are 6.08%; 4.38%; 3.77%; and 2.55% for 2001; 2002; 2003; and 2004, respectively. Therefore, it appears that most banks complied with the nonperforming loan ratio requirement of the government regulation in 2002.

The mean (median) of the capital adequacy ratio[8] from 2000 to 2004 is 10.41% (10.31%) which is higher than the minimum 8% official requirement. The means (medians) for each year are 10.99% (10.26%); 10.59% (10.39%); 10.13% (10.21%); 10% (10.11%); and 10.32% (10.6%), respectively, for 2000 to 2004. These findings suggest that the banks may have adopted the 8% capital adequacy requirement of the Basel accord prior to the FFR period.

4.2 FFR Impact on banking efficiency

4.2.1 Univariate analysis

We first use the DEA model in (1) to estimate inefficiency for each bank for the five year period 2000-2004 using observed data on input-output vectors. We present the descriptive statistics for operating inefficiency in Table 2.

[Insert Table 2 here]

As reported in Table 2, the mean (median) of operating inefficiency is 1.2192 (1.1622)

[8] Capital adequacy ratio is defined as a measure of the amount of a bank's capital expressed as a percentage of its risk weighted credit exposures. Taiwan's bank capital adequacy ratio calculation is in accordance with international standards.

for the full sample period 2000-2004. The operating inefficiency of banks, on average, increased from 2000 to 2002, reaching its highest level in 2002. Also, operating inefficiency had increased approximately 18.2% in 2002 compared to 2000. The mean (median) operating inefficiency value during the pre-reform period is 1.1805 (1.1223), increasing to 1.2891 (1.224), its worse level, during the reform period, and decreasing to 1.1566 (1.0913) during the post-reform period.

As described, we used two DEA-based tests and three traditional tests (Welch test, Mann-Whitney test, and Kolmogorov-Sminrov test) to evaluate the inefficiency differences of banks between the reform period (2002-2003) of the FFR and the pre- (2000-2001) and post- (2004) reform periods. Results of the two DEA-based tests are shown in Table 3 along with the traditional tests for inefficiency differences between two groups.

From Table 3, we observe that the mean difference in inefficiency between the reform period and the other periods is statistically significant at the 1% level from the DEA-based statistical tests, indicating that banking operating efficiency was lower during the reform period. Similarly, results of the three non-DEA-based statistical tests indicate that the mean difference in operating inefficiency between the pre-FFR and FFR periods, as well as between FFR and the post-FFR periods is statistically significant at conventional level, suggesting that bank efficiency deteriorated in the reform period (H_1), but improved in the post-reform period (H_2). Thus, our hypotheses H_1 and H_2 are confirmed.

[Insert Table 3 here]

4.2.2 Multivariate analysis

We expect that the FFR program will shift the bank's business process; we model this potential shift as an interrupted time series and evaluate it using intervention analysis (Banker et al., 1989). Specifically, we specify the regression model to evaluate how the intervention

impacts the operating inefficiency from 2000 to 2004. Two dummy variables, *REFORM* and *POST*, are included as intervention variables to differentiate among the pre-reform, reform, and post-reform periods and to reflect the operating inefficiency difference among the three periods. As discussed in section 2, nonperforming loans have been found to be negatively associated with banking efficiency while capital adequacy has been found to be positively associated with banking efficiency. Further, since FFR required banks to have a minimum capital adequacy ratio of 8% and a maximum nonperforming loan ratio of 5% by the end of 2003, we expect banks to comply with these two requirements. Thus, we include the nonperforming loan ratio (*NPL*), capital adequacy ratio (*CA*), changes in the nonperforming loan ratio (ΔNPL), and changes in the capital adequacy ratio (ΔCA) in our regression models. Finally, prior studies in banking efficiency observe that bank operating efficiency was affected by its ownership type and size. Therefore, we also include a dummy variable (*OWN*) for private banks and the natural logarithm of total asset (*lnTA*) to proxy for bank size. Specifically, we specify and estimate the following two fixed-effects regression models:

$$\ln\theta = \beta_0 + \beta_1 NPL + \beta_2 CA + B_3 REFORM + B_4 POST + \beta_5 OWN + \beta_6 lnTA + \varepsilon \quad (4a)$$

$$\begin{aligned}\ln\theta = {} & \beta_0 + \beta_1 NPL + \beta_2 CA + B_3 REFORM + B_4 POST + \beta_{31} REFORM^{*}\Delta NPL \\ & + \beta_{32} REFORM^{*}\Delta CA + \beta_{41} POST^{*}\Delta NPL + \beta_{42} POST^{*}\Delta CA \\ & + \beta_5 OWN + \beta_6 lnTA + \varepsilon \end{aligned} \quad (4b)$$

where $\ln\theta$ is the natural logarithm of the inefficiency estimator θ obtained from equation (1); *NPL* is nonperforming loan ratio and defined as total due loans divided by total loans; *CA is* capital adequacy ratio; *REFORM* takes a value of 1 for 2002 and 2003, and 0 otherwise; *POST* takes a value of 1 for 2004, and 0 otherwise; ΔNPL is the change in nonperforming loan ratio; ΔCA is the change in the capital adequacy ratio; *OWN* is an indicator for private banks[9]; *lnTA* is

[9] There are 11 public banks each year in our sample.

the natural logarithm of total assets; and ε is the disturbance term.

Note that *REFORM* and *POST* are included to capture the difference in inefficiencies between the two years in the pre-FFR and FFR periods and between the two years in the FFR period and one year in the post-FFR period. These dummies and their corresponding interactions enable us to evaluate whether there is a significant change in the operating efficiency of commercial banks in Taiwan both before and after the FFR.

Our research design using the two-stage procedures represented in (4a) and (4b) is motivated by prior research. For instance, Chang et al. (2004) regress DEA scores on a variety of hospital specific characteristics in their study of health care regulation and the operating efficiency of hospitals. Further, Banker and Natarajan (2008) have provided theoretical justification for the use of the two-stage models in DEA to evaluate contextual variables affecting DEA efficiency scores.

We present regression results in Table 4. From Table 4 (4a and 4b), we observe that the coefficients of *NPL* are positive (0.0078 and 0.0073) and CA are insignificantly negative (-0.0012 and -0.0028), respectively, indicating that the higher the nonperforming loan ratio the higher the inefficiency. These results are consistent with findings of prior studies on banking efficiency that the nonperforming loan ratio is positively associated with the operating inefficiency as described earlier.

The coefficients of *REFORM* in (4a and 4b) are all significantly positive at a 1% level indicating that bank operating efficiency declined during the reform period (2002 to 2003). The coefficients for *POST* are negative, indicating that bank operating efficiency improved post FFR period compared to the pre-FFR period. The results of statistical tests of efficiency changes during the FFR period and between the post and FFR periods are also reported in Table 4.

Evidently, our hypotheses H_1 and H_2 are confirmed. That is, bank operating efficiency deteriorates in the reform period but improves in the post-reform period.

[Insert Table 4 here]

4.3. Sensitivity analyses

To evaluate the robustness of our empirical results, we conduct the following additional analyses. First, we check serial correlation for our residuals using Durbin-Watson test and we do not find evidence of autocorrelation. Second, we use Belsley, Kuh, and Welsch's (1980) diagnostics for collinearity and we do not find evidence of collinearity between contextual variables in our regression models. Third, we check heteroscedasticity for our residuals using White's (1980) test and we find evidence of heteroscedasticity. However, the results using White adjusted statistics reveal no appreciably difference from what we discussed earlier. Fourth, we use the CCR model of DEA (Charnes et al., 1978) to estimate the inefficiency for commercial banks and we find results similar to those of BCC discussed earlier. Finally, we follow Yeh (1996) and Kao and Liu (2004) to consider three inputs and three outputs by adding total deposits and total loans to our estimation of operating inefficiency. The results (not reported here) are similar to those discussed for the two inputs and two outputs specification case. Therefore, we conclude that our results are robust.

5. Conclusion

The current study investigates the impact of the FFR regulation on the operating efficiency of 40 commercial banks in Taiwan during 2000 to 2004. Using data over this five year period, two years before and one year after the FFR and two years during the FFR implementation, the results show that the efficiency of commercial banks in Taiwan deteriorated

during the implementation of the FFR. Specifically, banks had lower operating efficiency during the FFR reform period (2002-2003) compared to the pre-reform period (2000-2001) but had higher operating efficiency in the post-reform period (2004). This suggests that more time might be needed to reap the long-term benefits of restructuring.

We also find that banks with higher nonperforming loan ratios had lower operating efficiency and those with higher capital adequacy ratios had higher operating efficiency. Achieving the mission of the reform, the mean of nonperforming loan ratio had decreased to 3.89% in 2004 from a peak of 8.22% in 2001 and the capital adequacy ratio was consistently above the regulatory requirement, reaching a peak of 10.32% in 2004. The 5% floor of the nonperforming loan ratio was accomplished by substantial bad debt write-offs and accelerating the aging of loans, resulting in lower operating efficiency during the reform period. Overall, our results indicate that the FFR lead to improved operating efficiency in the banking sector, possibly due to the reduction of nonperforming loans rather than the boosting of capital adequacy during FFR.

The results of the current study have implications for the design of public policy by providing evidence to policymakers of the effectiveness of the FFR. In addition, given an increasingly competitive environment where inefficient institutions are less likely to survive, it is essential for regulators and managers to be knowledgeable about inefficiencies in the banking industry and factors (such as nonperforming loans and capital adequacy) that may exacerbate or mitigate them. Also, the results reported here suggest that lower nonperforming loans, not higher capital adequacy, are primarily responsible for improved operating efficiency, although both are critical indicators of banking operating efficiency. Thus, future regulations should target the prevention and reduction of nonperforming loans in an effort to improve banking

efficiency.

Our results suggest several avenues for future research. First, a theory is needed to explain the nonlinear reform-efficiency relationship documented over the pre-reform, during reform, and post-reform periods. The development of such a theory or model would serve as a guide for regulatory authorities. Second, future research could examine the long-term implications of restructuring beyond the one-year post-reform period considered in the current study. Third, while we chose to study the efficiency effects of FFR, future research could examine the effects of such regulatory changes on accounting and financing choices.

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Table 1: Descriptive statistics on inputs, outputs, and the "First Financial Restructuring" variables (*N*=40 each year)

Panel A: Inputs

Variable	YEAR	Mean	Std Dev	Q1	Median	Q3
Output items						
Interest	2000	18940.1	20343.5	7186.3	9675.0	23216.5
Expense (x_1)	2001	18037.3	18987.0	7478.1	9782.5	21912.1
	2002	10408.9	11481.9	4195.4	5526.7	12252.5
	2003	6781.0	7494.2	2610.7	3534.2	8533.7
	2004	6251.7	7093.2	2382.9	3090.2	8568.0
	2000-2004	12083.8	15102.6	3112.9	6321.7	12165.6
Non-interest	2000	8998.8	8194.7	3437.3	5350.0	9592.5
Expense (x_2)	2001	11103.2	10742.3	3907.4	5587.2	14380.5
	2002	14323.1	14693.4	4996.7	8067.5	17677.3
	2003	11422.2	11072.0	4655.9	7108.9	16667.9
	2004	10432.0	8386.2	5405.4	7602.8	14315.9
	2000-2004	11255.9	10906.8	4491.9	6743.3	14893.9

Interest expense: interest expense of bank per year
Non-interest expense: includes the expenditures of transaction and commission, personnel, and other operating related expense
All dollar amounts expressed in million New Taiwan Dollars and deflated to 2000.

Panel B: Outputs

Variable	YEAR	Mean	Std Dev	Q1	Median	Q3
Output items						
Interest revenue	2000	$26481.3	$26722.0	$10439.8	$13761.5	$33371.3
(y_1)	2001	26300.9	26444.0	10340.0	14154.2	34064.4
	2002	19591.3	18799.5	7927.3	10982.4	28863.3
	2003	15189.8	13195.9	6890.3	8880.2	24002.2
	2004	14539.5	11936.7	6370.5	9382.3	23027.6
	2000-2004	20420.6	20862.1	7895.5	11432.1	28857.0
Non-interest	2000	4053.9	4590.3	1226.8	2434.5	4830.8
Revenue (y_2)	2001	4801.7	5329.0	1448.3	2963.6	5554.4
	2002	3692.3	4203.5	1003.0	1958.7	3984.4
	2003	4758.9	4461.1	1336.1	3140.1	6190.4
	2004	5655.5	5694.3	1868.2	3670.6	6792.7
	2000-2004	4592.5	4886.2	1292.1	2833.5	6018.1

Interest revenue: interest revenue of the bank
Non-interest revenue: comprises transaction fee and commission revenue, bond transaction revenue, and other operating revenue
All dollar amounts expressed in million New Taiwan Dollars and deflated to 2000.

Panel C: FFR policy variables

Variables	YEAR	Mean	Std Dev	Q1	Median	Q3
NPL	2000	5.88	4.51	2.69	4.40	7.16
	2001	8.22	6.52	4.00	6.08	9.42
	2002	7.01	6.44	3.15	4.38	7.73
	2003	5.62	5.53	2.23	3.77	5.98
	2004	3.89	4.25	1.63	2.55	4.20
	2000-2004	6.12	5.66	2.57	4.24	7.48
CA	2000	10.99	3.08	9.18	10.26	12.05
	2001	10.59	2.33	9.20	10.39	11.63
	2002	10.13	2.77	8.98	10.21	11.79
	2003	10.00	2.19	8.93	10.11	11.03
	2004	10.32	2.11	9.51	10.60	11.60
	2000-2004	10.41	2.53	9.18	10.31	11.53
TA	2000	470668.8	512695.6	165244	224785	633547.8
	2001	522310.3	567590.6	183498.7	258025.9	744121.4
	2002	513789.7	550452.2	175076.8	247293.1	666350.7
	2003	555212.3	581373.1	193062.6	263941.1	798608.7
	2004	565533.4	570387.9	195316.8	283918.7	771300.7
	2000-2004	525502.9	556434.9	172729.2	255592.8	727108.0

NPL: nonperforming loan ratio, total due loans/ total loans
CA: capital adequacy ratio, amount of a bank's capital expressed as a percentage of its risk weighted credit exposures
TA: total assets measured in New Taiwan Dollars and deflated to 2000.

Table 2: Descriptive statistics of operating inefficiencies (*N*=40)

Year	Mean	Std. Dev.	Median
2000	1.1545	0.1750	1.0820
2001	1.2065	0.1975	1.1645
2002	1.3640	0.3315	1.2379
2003	1.2142	0.1405	1.2194
2004	1.1566	0.1956	1.0913
Pre-FFR period (2000 & 2001)	1.1805	0.1872	1.1223
FFR period (2002 & 2003)	1.2891	0.2640	1.2240
Post- FFR period (2004)	1.1566	0.1956	1.0913
Whole sample period (2000-2004)	1.2192	0.2290	1.1622

Table 3: Statistical test results of equality of inefficiencies (*N*=40)

		FFR Period Vs. Pre-FFR Period	FFR Period Vs. Post-FFR Period
		Test-statistics (p-values)	Test-statistics (p-values)
DEA-Based tests	T_{EXP}	1.602*** (0.00)	1.846*** (0.00)
	T_{HN}	2.268*** (0.00)	2.464*** (0.00)
Conventional tests	Welch	3.00*** (0.00)	3.10*** (0.00)
	Mann-Whitney	3.234*** (0.00)	3.467*** (0.00)
	Kolmogorov-Smirnov	1.739*** (0.00)	1.872*** (0.00)

$T_{exp} = [\sum_{j\in N1}(\theta_j - 1)/N1]/[\sum_{j\in N2}(\theta_j - 1)/N2]$, $T_{hn} = [\sum_{j\in N1}(\theta_j - 1)^2/N1]/[\sum_{j\in N2}(\theta_j - 1)^2/N2]$.

*significant at the 10% level;** significant at the 5% level;*** significant at the 1% level.

Table 4: Regression results of the impact of the "First Financial Restructuring" on banking efficiency (p-values in parentheses)

$$\ln\theta = \beta_0 + \beta_1 NPL + \beta_2 CA + B_3 REFORM + B_4 POST + \beta_5 OWN + \beta_6 LnTA + \varepsilon \quad (4a)$$

$$\ln\theta = \beta_0 + \beta_1 NPL + \beta_2 CA + B_3 REFORM + B_4 POST + \beta_{31} REFORM^{*}\Delta NPL + \beta_{32} REFORM^{*}\Delta CA + \beta_{41} POST^{*}\Delta NPL + \beta_{42} POST^{*}\Delta CA + \beta_5 OWN + \beta_6 LnTA + \varepsilon \quad (4b)$$

Variables	Coefficients	Pred. Signs	Regression Models (4a)	(4b)
Intercept	β_0		0.3077	0.2505
			(0.20)	(0.31)
NPL	β_1	+	0.0078***	0.0073***
			(0.00)	(0.00)
CA	β_2	-	-0.0012	-0.0028
			(0.81)	(0.57)
REFORM	B_3	+	0.0900***	0.0834***
			(0.00)	(0.00)
POST	B_4	-	-0.0062	-0.0243
			(0.84)	(0.55)
$REFORM^{*}\Delta NPL$	β_{31}		---	-0.0013
				(0.86)
$REFORM^{*}\Delta CA$	β_{32}		---	-0.0164*
				(0.09)
$POST^{*}\Delta NPL$	β_{41}		---	0.0151
				(0.32)
$POST^{*}\Delta CA$	β_{42}		---	0.0111
				(0.66)
OWN	β_5		0.033	0.0366
			(0.32)	(0.28)
lnTA	β_6		-0.0194	-0.0162
			(0.22)	(0.32)
Adj *R-Sq*			0.1756	0.1762
F-statistic			8.07***	5.26***
			(0.00)	(0.00)
Statistical tests of efficiency changes			*F*-statistics (*p*-values)	*F*-statistics (*p*-values)
H_1: Bank operating efficiency drops during the reform period of the FFR	$\beta_3 > 0$		13.72***	---
			(0.00)	
	$\beta_3 + \beta_{31} * \Delta NPL + \beta_{32} * \Delta CA > 0$		---	12.39***
				(0.00)
H_2: Bank operating efficiency improves in the post-reform	$\beta_3 > \beta_4$		8.02***	---

period compared to the reform		(0.00)	
period of the FFR	$\beta_3 + \beta_{31} * \Delta NPL + \beta_{32} * \Delta CA$	---	7.88***
	$> \beta_4 + \beta_{41} * \Delta NPL + \beta_{42} * \Delta CA$		(0.00)

*significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

$\ln \theta$ = natural logarithm of the inefficiency estimator θ obtained from equation (1) and other variable definitions appear in Table 1.