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FINANCIAL REPRESSION, LIBERALIZATION AND BANK TOTAL FACTOR PRODUCTIVITY: EMPIRICAL EVIDENCE FROM THE THAILAND BANKING SECTOR

Abstract. *The present paper employs the Malmquist Productivity Index (MPI) method to examine sources of total factor productivity change of the Thailand banking sector during the post-Asian financial crisis period of 1999-2008. The empirical findings suggest that the Thailand banking sector has exhibited productivity regress during the period under study due to technological regress. The results indicate that the domestic banks have exhibited productivity regress due to technological regress, while the foreign banks have exhibited productivity progress attributed to technological progress. Credit risk and diversification have negative impacts on Thailand banks' total factor productivity. On the other hand, the better capitalized and profitable Thailand banks tend to be relatively more productive. During the period under study, business cycle display mixed impacts. The empirical findings seem to suggest that the different structures of bank ownership have no significant impact on bank productivity.*

Keywords*: Banks, Total Factor Productivity, Malmquist Productivity Index, Panel Regression Analysis, Thailand.*

JEL Classification: G21

1.0 INTRODUCTION

Banks play significant roles in mobilizing savings to fuel investments and growth. This role is particularly significant in Thailand where banks continue to dominate the financial markets. As at end- 2008, banks accounts for 64.2% of the financial system's total assets. Expansionary economic activities by corporations and the government are mostly financed by the banking sector. About 61.1% of the credit requirements of local companies in Thailand are supplied by banks, while only 32.4%

by the capital markets. The dominance of banks can be explained by many factors, among others the underdevelopment of the capital markets.

Apart from its role in financial intermediation, banks have been shown to contribute to general economic stability. This integral link was evident during the Asian financial crisis, where the Thailand economy was adversely affected when banks have been weak and vulnerable to external shocks. Earlier studies have suggested that fragilities in the banking system played key roles in propagating the financial crisis that halted the momentum of the so-called East Asian growth miracle in the mid-1990. The crisis caused the affected economies, as well as Thailand, to slow down arising from among others the pull out of investors, currency depreciations, higher interest rates, and large debt overhang.

Since the Asian financial crisis, a number of significant changes have occurred in the Thailand banking sector as a result of its adaptation to new conditions such as the deregulation of the national markets and the internationalization of competition. To develop Thailand as a regional financial center, the central bank, Bank of Thailand (BOT) has allowed qualified financial institutions operating the Bangkok International Banking Facilities (BIBFs) since 1993 and in other provinces (PIBFs) since 1994. A license for international banking facilities permits domestic commercial banks and foreign bank branches to provide acceptance of deposits in foreign currencies, lending in foreign currencies to both residents (out-in lending) and non-residents (out-out lending), and foreign exchange transactions. That is, mobilization of foreign savings to finance the country's economic growth has become more flexible. In 1998, 10 Thai banks and 35 foreign bank branches have been granted permission to establish BIBF offices, while another 23 foreign bank branches are allowed to get PIBF licenses in other provinces.

It is reasonable to assume that these developments posed great challenges to banks operating in the Thailand banking sector as the environment in which they operate changed rapidly. Golin (2001) points out that, adequate earnings are required in order for banks to maintain solvency, to survive, grow, and prosper in a competitive environment. Furthermore, the earlier studies by among others Rajan and Zingales (1998) showed that there is a close relationship between the growth of the economy and the well being of the banking sector. Therefore, knowledge of the underlying factors that influence the performance of the banking sector is essential not only for the managers of the banks, but for numerous stakeholders such as the central bank, bankers association, the government, and other financial authorities. Knowledge of these factors would be helpful for the regulatory authorities and bank managers to formulate going forward policies for the Thailand banking sector.

By using the whole gamut of commercial banks operating in the Thailand banking sector, the present paper seeks to examine the performance of the Thailand banking sector during the post Asian financial crisis period of 1999-2008, which is characterized as a time of significant restructuring in the country's financial sector.

The paper also investigates to what extent the performance of commercial banks is influenced by internal factors (i.e. bank specific characteristics) and to what extent by external factors (i.e. macroeconomic and banking sector conditions). We differentiate this paper from the previous ones that focus on the Thailand banking sector and contribute to the present literature in at least three important ways.

Firstly, we employ two different estimating principles. The DEA based Malmquist Productivity Index (MPI) method, which is one of the techniques we employ, is a non-parametric and oriented to frontier rather than central tendency estimates (Cooper *et al*. 2006). Unlike the previous studies focusing on the Thailand banking sector, the present study adopts a dynamic panel of the MPI method. Furthermore, Isik and Hassan (2002) point out that the dynamic panel is more flexible and thus more appropriate than estimating a single multiyear frontier for the banks in the sample.

Secondly, following the more recent approach suggested by Chang *et al*. (2009) among others, we also use the central tendency and parametric method that are involved in a random effects panel regression analysis to investigate the Thailand banking sector's production efficiency, while controlling for the potential effects of the contextual variables. In this way, we protect against the 'methodological bias' that can occur when only one method is used (see the exchange between Evans and Heckman (1988) and Charnes *et al*. (1988)). Although this approach has been used in some of the earlier studies, in our case we examine a more recent period that follows the changes outlined above.

This paper is structured as follows. The next section reviews the related studies in the literature. In section 3, we outline the approaches to the measurement and estimation of total factor productivity change, justify our use of what is called the "intermediation approach" to the measurement of bank inputs and outputs, outlines the econometric framework, and provide details on the construction of our data set. Section 4 discusses the results, and finally section 6 provides some concluding remarks and policy implications.

2.0 A BRIEF REVIEW OF RELATED LITERATURE

Since its introduction by Charnes *et al*. (1978) and Banker *et al*. (1984), researchers have welcomed Data Envelopment Analysis (DEA) as a methodology for performance evaluation (Gregoriou and Zhou, 2005). However, a large body of literature exists on banking efficiency in the United States (see surveys by Berger and Humphrey, 1997; Berger, 2007 and references therein) and the banking systems in the western and developed countries (Sathye, 2001; Hauner, 2005; Pasiouras, 2008; etc). On the other hand, relatively few have been conducted within the developing economies banking sectors (Berger and Humphrey, 1997).

Despite substantial studies performed in regard to the efficiency and productivity of financial institutions in the U.S., Europe, and other developed

countries banking sectors, empirical evidences on the developing countries banking sectors, particularly Thailand are relatively scarce. To date, the studies by Leightner and Lovell (1998) and Williams and Intrachote (2003) are the two most notable empirical research performed to examine the efficiency of the Thailand banking sector. The earlier study by Leightner and Lovell (1998) found mixed performance of the foreign owned banks during the period of 1989 to 1994. They suggest that the large domestically owned banks to be the most efficient, while the foreign owned banks have exhibited slightly higher efficiency level compared to the medium sized domestic owned banks. The smaller domestic owned banks were found to be the most inefficient banks.

A more recent study by Williams and Intrachote (2003) conclude that the efficiency of the foreign and domestic owned banks during the period of 1990 to 1997 were comparable. By employing the Stochastic Frontier Approach (SFA), they found that the Japanese owned banks in Thailand to be significantly more efficient compared to their domestic owned bank counterparts and foreign banks from other nations. Their results supports to the view that foreign owned banks from strong home environments may carry efficiency advantages overseas.

The above literature reveals the following research gaps. First, the majority of these studies concentrate on the banking sectors of the developed countries, such as the U.S., Europe and other developed countries banking sectors. Second, empirical evidence on the developing and emerging countries are relatively scarce. Finally, apart from the few studies discussed above, virtually nothing has been published to examine the sources of total factor productivity of the Thailand banking sector during the post-Asian financial crisis period. In the light of these knowledge gaps, this paper seeks to provide new empirical evidence on the sources of total factor productivity change in the Thailand banking sector.

3.0 METHODOLOGY AND DATA

3.1 Malmquist Productivity Index (MPI)

Three different indices are frequently used to evaluate total factor productivity changes: the Fischer (1922), Tornqvist (1936), and Malmquist (1953) indices. The non-parametric (Malmquist) and parametric (Fischer and Tornqvist) indices differ in several ways in respect to their behavioural assumptions and whether or not they recognize random errors in the data (noise). Grifell-Tatje and Lovell (1996) suggest that the Malmquist Productivity Index (MPI) has several distinct advantages over the Fischer and Tornqvist indices.

Firstly, it does not require the profit maximization, or the cost minimization assumption. Secondly, it does not require information on the input and output prices. Thirdly, if the researcher has panel data, it allows the decomposition of productivity changes into two components (technical efficiency change or catching up and

technical change or changes in the best practice). Finally, unlike the parametric methods, it does not require specifying the functional form for the frontier, which could be biased due to specification errors if the functional form is mis-specified. Its main disadvantage is the necessity to compute the distance functions. However, the Data Envelopment Analysis (DEA) technique can be used to solve this problem.

Following Fare *et al*. (1994) among others, the present study adopts the output oriented Malmquist Productivity Index (MPI). The analysis employs the notion of an output distance function first proposed by Shephard (1970), which measures how much a unit's outputs can be proportionately increased given the observed levels of its inputs. The structure of the production technology is assumed to exhibit constant returns to scale (CRS). We delineate the structure of production technology with the output distance function as follows:

$$D^t(x_j^t, y_j^t) = \min\left\{ \phi \mid (x_j^t, y_j^t/\phi) \in P^t \right\}, \quad (1)$$

which measures the output technical efficiency of bank *j* at time *t* relative to the technology at time *t* (Shephard, 1970). Since technical efficiency is measured relative to the contemporaneous technology, we have $D^t(X_j^t, Y_j^t) \leq 1$, with $D^t(X_j^t, Y_j^t) = 1$ signifying that unit *j* is on the production frontier and is technically efficient, while $D^t(X_j^t, Y_j^t) < 1$ indicating that the unit is below the frontier and is technically inefficient.

Before describing the MPI method, we need to define distance functions with respect to two different time periods. The efficiency of unit *j* at time *t* relative to the technology at time *t+1* is represented by

$$D^{t+1}(x_j^t,\ y_j^t) = \min\left\{ \phi \mid (x_j^t,\ y_j^t/\phi) \in P^{t+1} \right\}. \quad (2)$$

Similarly, the efficiency of unit *j* at time *t+1* relative to the technology at time *t* is defined by the distance function

$$D^t(x_j^{t+1}, y_j^{t+1}) = \min\left\{ \phi \mid (x_j^{t+1},\ y_j^{t+1}/\phi) \in P^t \right\}. \quad (3)$$

Caves *et al*. (1982) define the MPI as

$$M^t(x_j^{t+1}, y_j^{t+1}, x_j^t, y_j^t) = \frac{D^t(x_j^{t+1}, y_j^{t+1})}{D^t(x_j^t, y_j^t)}$$

or

$$M^{t+1}(x_j^{t+1}, y_j^{t+1}, x_j^t, y_j^t) = \frac{D^{t+1}(x_j^{t+1}, y_j^{t+1})}{D^{t+1}(x_j^t, y_j^t)} \quad . \tag{4}$$

The indices in equation (4) provide measures of productivity changes. To avoid choosing an arbitrary benchmark, two continuous MPI are combined into a single index by computing the geometric mean and then multiplicatively decomposed this index into two sub-indices measuring changes in technical efficiency and technology as follows:

$$\Delta Eff^{t,t+1} = \frac{D_c^{t+1}(x_j^{t+1}, y_j^{t+1})}{D_c^t(x_j^t, y_j^t)} \tag{5}$$

and

$$\Delta Tech^{t,t+1} = \left[\frac{D_c^t(x_j^{t+1}, y_j^{t+1})}{D_c^{t+1}(x_j^{t+1}, y_j^{t+1})} \times \frac{D_c^t(x_j^t, y_j^t)}{D_c^{t+1}(x_j^t, y_j^t)} \right]^{1/2} . \tag{6}$$

The ratio in equation (5) is an index of technical efficiency change between periods *t* and *t+1*, measuring whether unit *j* moves closer to or farther away from best practices during the time period. The value of $\Delta Eff^{t,t+1}$ is greater than, equal to, or less than unity depending on whether the relative efficiency of unit *j* is improved, unchanged, or declined during the period. The term $\Delta Tech^{t,t+1}$ in equation (6) is an index of technology change, which gives the geometric mean of two ratios. A value of $\Delta Tech^{t,t+1}$ greater than, equal to, or less than unity indicates progress, no change, or regression in technology, respectively between periods *t* and *t+1*.

From equations (5) and (6), the relationship between the MPI and its two sub-indices is

$$M^{t,t+1} = \Delta Eff^{t,t+1} \times \Delta Tech^{t,t+1} . \tag{7}$$

Clearly, productivity change is the decomposition of changes in both efficiency and technology with $M^{t,t+1}$ greater than, equal to, or less than unity representing progress, stagnation, or regress in total factor productivity, respectively between periods *t* and *t+1*. In principle, one may calculate the MPI in (7) relative to

any technology pattern. The CRS technology is adopted to compute the MPI and its two sub-indices in the preceding analysis.

The $\Delta Eff^{t,t+1}$ index can be further disaggregated into its mutually exhaustive components of pure technical efficiency change $\Delta PureEff^{t,t+1}$ calculated relative to the variable returns to scale (VRS) technology and a component of scale efficiency change $\Delta Scale^{t,t+1}$ capturing changes in the deviation between the VRS and CRS technologies. That is,

$$\Delta Eff^{t,t+1} = \Delta PureEff^{t,t+1} \times \Delta Scale^{t,t+1}, \tag{8}$$

where

$$\Delta PureEff^{t,t+1} = \frac{D_v^{t+1}(x_j^{t+1},\ y_j^{t+1})}{D_v^{t}(x_j^{t},\ y_j^{t})}, \tag{9}$$

$$\Delta Scale^{t,t+1} = \frac{D_c^{t+1}(x_j^{t+1},\ y_j^{t+1}) \big/ D_v^{t+1}(x_j^{t+1},\ y_j^{t+1})}{D_c^{t}(x_j^{t},\ y_j^{t}) \big/ D_v^{t}(x_j^{t},\ y_j^{t})} \tag{10}$$

The subscripts "*v*" and "*c*" denote VRS and CRS technologies, respectively. $\Delta PureEff^{t,t+1} > 1$ indicates an increase in pure technical efficiency, while $\Delta PureEff^{t,t+1} < 1$ indicates a decrease and $\Delta PureEff^{t,t+1} = 1$ indicates no change in pure technical efficiency. Similarly, $\Delta Scale^{t,t+1} > 1$ implies that the most efficient scale is increasing over time, so the scale efficiency is improving, while $\Delta Scale^{t,t+1} < 1$ implies the opposite, and $\Delta Scale^{t,t+1} = 1$ indicates that there is no change in scale efficiency.

3.2 Specification of Bank Inputs, Outputs

The definition and measurement of inputs and outputs in the banking function remains a contentious issue among researchers. In the banking theory literature, there are two main approaches competing with each other in this regard: the production and intermediation approaches (Sealey and Lindley, 1977). Under the production approach, pioneered by Benston (1965), a financial institution is defined as a producer of services for account holders, that is, they perform transactions on deposit accounts and process documents such as loans. The intermediation approach on the other hand assumes that financial firms act as an intermediary between savers and borrowers and posits total loans and securities as outputs, whereas deposits along with labour and physical capital are defined as inputs.

For the purpose of this study, a variation of the intermediation approach or asset approach originally developed by Sealey and Lindley (1977) will be adopted in the definition of inputs and outputs used. According to Berger and Humphrey (1997), the production approach might be more suitable for branch efficiency studies as at most times bank branches process customer documents and bank funding, while investment decisions are mostly not under the control of branches.

Accordingly, we model Thailand banks as multi-product firms, producing three outputs by employing three inputs. All variables are measured in million of Thai Baht (THB). The input vectors used in the study are (*x1*) *Total Deposits*, which includes deposits from customers and other banks, (*x2*) *Fixed Assets*, and (*x3*) *Labour*, while (*y1*) *Total Loans*, which includes loans to customers and other banks, (*y2*) *Investments*, and (*y3*) *Non-Interest Income* are the output vectors. Table 1 presents the summary statistics of the input and output variables employed in the study.

Table 1: Summary Statistics of the Variables Employed in the MPI Model

	Inputs			**Outputs**		
	Total Deposits (*x1*)	**Fixed Assets (*x2*)**	**Labour (*x3*)**	**Total Loans (*y1*)**	**Investments (*y2*)**	**Non-Interest Income (*y3*)**
Mean	372.62	142.18	5.94	436.10	17.92	4.38
Min	3.38	1.55	0.03	9.48	0.25	0.05
Max	9365.10	2939.70	99.40	7128.90	145.00	86.40
Std. Dev.	914.03	284.88	9.29	767.55	20.16	8.99

Source: Fitch IBCA Bank Scope

3.3 Multivariate Regression Analysis Framework

The research design to correlate the contextual variables affecting the total factor productivity scores in a two-stage regression model is supported by recent developments. In an influential development, Banker and Natarajan (2008) provide proof that the use of a two-stage procedure involving DEA followed by an Ordinary Least Square (OLS) regression yields consistent estimators of the regression coefficients. Moreover, in an important development, McDonald (2009) provide statistical foundation that the use of DEA and OLS is a consistent estimator, and if White's (1980) heteroskedastic consistent standard errors are calculated, large sample tests can be performed, which are robust to heteroskedasticity and the distribution of the disturbances.

Thus, following Banker and Natarajan (2008) among others, equation (11) is estimated by using the Ordinary Least Square (OLS) method. As suggested by McDonald (2009), we estimate equation (11) by using White (1980) transformation, which is robust to heteroskedasticity and the distribution of the disturbances in the second stage regression analysis. In order to check for the robustness of the results, following Chang *et al*. (2009) among others, we control for bank specific effects by applying the least square method of the random effects (RE) model. The opportunity to use a random effects rather than a fixed effects model has been tested with the Hausman test. The standard errors are again computed by using White's (1980) transformation to control for cross section heteroscedasticity of the variables.

By using the TFPCH scores as the dependent variable, the following regression model is estimated:

$$\begin{aligned}\lambda_{jt} = {} & \delta_0 + \beta_1 LLP/TL_{jt} + \beta_2 NII/TA_{jt} + \beta_3 NIE/TA_{jt} + \beta_4 LOANS/TA_{jt} \\ & + \beta_5 LNTA_{jt} + \beta_6 EQASS_{jt} + \beta_7 ROA_{jt} \\ & + \zeta_1 LNGDP_t + \zeta_2 INFL_t + \zeta_3 CR3_t + \zeta_4 MKTCAP/GDP_t \\ & + \delta_1 DUMFORB_j + \delta_2 DUMGOVT_j + \delta_3 DUMPUBL_j \\ & + \varepsilon_{jt}\end{aligned} \qquad (11)$$

where '*i*' denotes the bank, '*t*' the examined time period, and ε is the disturbance term, with v_{it} capturing the unobserved bank specific effect and u_{it} is the idiosyncratic error and is independently identically distributed (i.i.d), $e_{it} \sim N(0,\sigma^2)$.

The independent variables and their hypothesized relationship with bank total factor productivity are detailed in Table 2.

Table 2: **Descriptive of the Variables Used in the Regression Models**

Variable	Description	Hypothesized Relationship
	Dependent	
TFPCH	Bank's total factor productivity scores derived from the MPI method.	NA
	Independent	
	Internal Factors	
LOANS/TA	Total loans over total assets.	+/-
LNTA	Natural logarithm of total assets.	+/-
LLP/TL	Loan loss provisions over total loans.	-
NII/TA	Non-interest income over total assets.	+
NIE/TA	Non-interest expense over total assets.	-
EQASS	Total book value of shareholders equity over total assets.	+

ROA	Return on assets.	+
	External Factors	
LNGDP	Natural logarithm of gross domestic products.	+
INFL	The annual inflation rate.	+/-
CR3	The three largest banks asset concentration ratio.	+/-
MKTCAP/GDP	The ratio of stock market capitalization. The variable serves as a proxy of financial development.	-
DUMCRIS	Dummy variable that takes a value of 1 for the crisis period, 0 otherwise.	-
	Bank Ownership	
DUMFORB	Dummy variable that takes a value of 1 for foreign banks, 0 otherwise.	+
DUMGOVT	Dummy variable that takes a value of 1 for government links banks, 0 otherwise.	-
DUMPUBL	Dummy variable that takes a value of 1 for publicly listed banks, 0 otherwise.	+/-

Source: The data for internal factors are obtained from Fitch IBCA Bank Scope database. The data for the external factors are sourced from International Monetary Fund (IMF) International Financial Statistics (IFS).

3.4 Data

This study employs annual bank level data for the domestic and foreign commercial banks operating in the Thailand banking sector during the period 1999 to 2008. The main source of data is the Bank Scope database maintained by Fitch/IBCA/Bureau van Dijk, which is considered as the most comprehensive database for research in banking. The number of observations varied across time due to missing observations for some banks for certain years. This gives us a total of 154 bank year observations.

4.0 EMPIRICAL FINDINGS

In this section, we will discuss the productivity change of the Thailand banking sector, measured by the MPI and assign changes in Total Factor Productivity Change (TFPCH) to Technological Change (TECHCH) and Efficiency Change (EFFCH). We will also attempt to attribute any change in EFFCH to changes in Pure Technical Efficiency (PEFFCH) and/or Scale Efficiency (SECH). The MPI analysis is based on a comparison of adjacent years, i.e. indices are estimated for 1999-2000, 2000-2001, 2001-2002, 2002-2003, 2003-2004, 2004-2005, 2005-2006, 2006-2007, and 2007-2008. Because the year 1999 is the reference year, the MPI and its components takes an initial score of 1.000 for the year 1999. Hence, any score greater

(lower) than 1.000 in subsequent years indicates an improvement (deterioration) in the relevant measure.

It is also worth mentioning that favorable efficiency change (EFFCH) is interpreted as evidence of "catching up" to the frontier, while favorable technological change (TECHCH) is interpreted as innovation (Cummins *et al*. 1999). Panels A, B, and C of Table 3 present the summary of annual means for the industry, the domestic, and foreign banks TFPCH, TECHCH, EFFCH, and its decomposition into PEFFCH and SECH for the years 1999-2008 respectively.

4.1 Total Factor Productivity Growth of Thailand Banks

As depicted in Panel A of Table 3, the MPI results suggest that during the period of 1999-2008, on average, the Thailand banking sector has exhibited productivity regress of 0.9%. The empirical findings from this study suggest that the Thailand banking sector has exhibited productivity decline during the years 2000, 2002, 2005, and 2008, while productivity was observed to have increased during the years 2001, 2003, 2004, and 2007. It is also observed from Panel A of Table 3 that the Thailand banking sector's productivity was stagnant during the year 2006. During the period under study, the decline in the Thailand banking sector's productivity was mainly due to technological change regress rather than efficiency change decline. The decomposition of the efficiency change index into its pure technical and scale efficiency components suggest that the source of the increase in Thailand banking sector's efficiency was mainly attributed to pure technical rather than scale efficiency, implying that Thailand banks have been managerially efficient in controlling their operating costs, but have been operating at the non-optimal scale of operations.

Panel B of Table 3 presents the results for the domestic banks. As observed, during the period under study, the empirical findings seem to suggest that the domestic banks have exhibited productivity regress of 1.9%. The decomposition of the productivity change index into its technological and efficiency change components suggest that the domestic banks' productivity were adversely affected by the regress in technological change of 2.6% during the years. The decomposition of the efficiency change index into its pure technical and scale efficiency components suggest that the dominant source of the increase in the domestic banks' efficiency were solely attributed to pure technical efficiency. This implies that although the domestic banks have been efficient in controlling their operating costs, they have been operating at the non-optimal scale of operations.

The results for the foreign banks operating in Thailand are presented in Panel C of Table 3. During the period under study, the results seem to indicate that the foreign banks have exhibited productivity progress of 3.0%. Unlike their domestic bank counterparts, the decomposition of the productivity change index into its mutually exhaustive components of technological and efficiency change suggest that the foreign banks have exhibited productivity progress mainly attributed to the

progress in technological change of 1.8% during the years. The empirical findings provides confirmation to the notion that the technical savvy of banks from developed countries would generally overcome the home field advantage of the domestic banks in developing countries, especially when the domestic economy has relatively unsophisticated financial markets and institutions (Sufian, 2009). The decomposition of the efficiency change index into its pure technical and scale efficiency components suggest that the increase in the foreign banks' efficiency were mainly attributed to pure technical rather than scale efficiency. Similar to their domestic bank peers, the results imply that the foreign banks have been efficient in controlling their operating costs, but were operating at the non-optimal scale of operations.

Table 3: **The Decomposition of Total Factor Productivity Change of Thailand Banks**

	Indices				
	Productivity Change (TFPCH)	**Technological Change (TECHCH)**	**Efficiency Change (EFFCH)**	**Pure Technical Efficiency Change (PEFFCH)**	**Scale Efficiency Change (SECH)**
			Panel A: *ALL BANKS*		
1999	1.000	1.000	1.000	1.000	1.000
2000	0.824	0.797	1.034	0.993	1.041
2001	1.025	1.007	1.017	1.057	0.963
2002	0.880	0.841	1.047	0.993	0.880
2003	1.082	1.136	0.952	0.983	0.969
2004	1.091	1.116	0.977	1.013	0.964
2005	0.869	0.762	1.140	1.034	1.103
2006	1.000	0.995	1.005	1.002	1.003
2007	1.592	1.707	0.933	1.022	0.913
2008	0.753	0.770	0.977	0.977	1.000
Geometric Mean	**0.991**	**0.984**	**1.007**	**1.007**	**0.982**
			Panel B: *DOMESTIC BANKS*		
1999	1.000	1.000	1.000	1.000	1.000
2000	0.841	0.804	1.046	1.000	1.046
2001	1.003	0.982	1.021	1.055	0.968
2002	0.904	0.855	1.057	1.003	1.054
2003	1.069	1.113	0.961	0.995	0.966
2004	1.026	1.092	0.940	0.989	0.950
2005	0.863	0.763	1.131	1.014	1.115
2006	0.970	0.956	1.015	1.010	1.005
2007	1.560	1.679	0.929	1.037	0.896
2008	0.752	0.766	0.982	0.986	0.996
Geometric Mean	**0.981**	**0.974**	**1.007**	**1.009**	**0.998**
			Panel C: *FOREIGN BANKS*		

1999	1.000	1.000	1.000	1.000	1.000
2000	0.762	0.770	0.990	0.969	1.021
2001	1.105	1.102	1.004	1.062	0.944
2002	0.807	0.795	1.016	0.962	1.057
2003	1.126	1.216	0.926	0.944	0.980
2004	1.418	1.226	1.157	1.125	1.028
2005	0.896	0.760	1.180	1.119	1.055
2006	1.094	1.122	0.975	0.976	0.998
2007	1.679	1.783	0.942	0.983	0.959
2008	0.753	0.782	0.964	0.952	1.012
Geometric Mean	**1.030**	**1.018**	**1.012**	**1.007**	**1.005**

Note: The mean scores of the Total Factor Productivity Change (TFPCH) index and its components, Technological Change (TECHCH) and Efficiency Change (EFFCH) that is further decomposed into Pure Technical Efficiency Change (PEFFCH) and Scale Efficiency Change (SECH), for All Banks (ALL BANKS) and different forms in the sample, Domestic Banks (DOMESTIC BANKS) and Foreign Banks (FOREIGN BANKS). Detailed results are available from the authors upon request.

4.2 Factors Influencing Banks' Total Factor Productivity

An important understanding that arises after the calculation of the MPI is to attribute variations in productivity change to bank specific characteristics and the environment in which they operate. Thus, the following section proceeds to discuss the results derived from the multivariate regression analysis framework. The regression results focusing on the relationship between bank total factor productivity and the explanatory variables are presented in Table 4. To conserve space, the full regression results, which include both bank and time specific random effects are not reported in the paper. Several general comments regarding the test results are warranted. The model performs reasonably well with most variables remain stable across the various regressions tested. The explanatory power of the models is also reasonably high and in most cases the *F*-statistics are also statistically significant at the 5% level or better.

As expected, the coefficient of LLP/TL exhibits a negative sign when we control for the recent global economic crisis and bank ownership forms. The results suggest that Thailand banks with higher credit risks tend to exhibit lower total factor productivity levels. If anything could be delved, the empirical findings imply that Thailand banks should focus more on credit risk management, which has been proven to be problematic in the recent past. Serious banking problems have arisen from the failure of banks to recognize impaired assets and create reserves for writing off these assets. An immense help towards smoothing these anomalies would be provided by improving the transparency of the banking system, which in turn will assist banks to evaluate credit risk more effectively and to avoid problems associated with hazardous exposure.

The coefficient of NII/TA has a negative sign and is statistically significant in all regression models. The results imply that banks which derived a higher proportion of its income from non-interest sources such as fee based services tend to be relatively less productive. The finding is in consonance with the earlier study by among others Stiroh (2006). To recap, Stiroh (2006) find that diversification benefits of the U.S. financial holding companies are offset by the increased exposure to non-interest activities, which are much more volatile, but not necessarily more profitable than interest generating activities.

Referring to the impact of overhead costs on Thailand banks' productivity, the coefficient of NIE/TA consistently exhibits positive and statistically significant impact on bank total factor productivity whether we control for the macroeconomic and financial markets variables or not. The findings imply that an increase (decrease) in these expenses results in a higher (lower) productivity of banks operating in the Thailand banking sector. The results indicates that the more productive Thailand banks tend to incur higher operating costs, which could be attributed to a more highly qualified and professional management. Sathye (2001) points out that the more highly qualified and professional management may require higher remuneration packages, therefore a positive relationship with performance measures is normal.

The proxy measure of bank liquidity, LOANS/TA exhibits negative relationship with bank productivity levels and is statistically significant when we control for the recent global financial crisis and the various bank ownership structures. The findings imply that banks with higher loans-to-asset ratios tend to be more productive. Thus, in the case of the Thailand banking sector, bank loans seem to be more highly valued than alternative bank outputs such as investments and securities. The result is consistent with earlier studies by among others Molyneux and Thornton (1992).

Concerning the impact of bank size, the coefficient of LNTA is negative indicating an inverse relationship between total factor productivity and bank size. Hauner (2005) offers two potential explanations for which size could have a positive impact on bank performance. First, if it relates to market power, large banks should pay less for their inputs. Second, there may be increasing returns to scale through the allocation of fixed costs (e.g. research or risk management) over a higher volume of services, or from efficiency gains from a specialized workforce. However, the results need to be interpreted with caution since the coefficient of the variable has not been statistically significant at any conventional levels in any of the regression models.

Capital strength as measured by EQASS is positively related to Thailand banks' total factor productivity. However, the coefficient of the variable is only statistically significant when we control for the foreign (DUMFORB) and government (DUMGOVT) own banks, but loses its explanatory power when we control for the publicly listed banks (DUMPUBL). The empirical finding is consistent with Pasiouras and Kosmidou (2007) providing support to the argument

that well capitalized banks face lower costs of going bankrupt, thus reduce their cost of funding. Furthermore, strong capital structure is essential for bank in developing economies, since it provides additional strength to withstand financial crises and increased safety for depositors during unstable macroeconomic conditions (Sufian, 2009).

The empirical findings seem to suggest mixed impact of the indicators of macroeconomic conditions on bank total factor productivity. The results about LNGDP support the argument of the association between economic growth and the performance of the banking sector. The high economic growth during the post-Asian financial crisis period could have encouraged Thailand banks to lend more and permits them to charge higher margins, as well as improving the quality of their assets. On the other hand, the rate of inflation (INFL) is negatively related to Thailand banks' total factor productivity. The results imply that during the period under study the levels of inflation have been unanticipated by Thailand banks resulting in the banks' costs to outpace their revenues and consequently had adverse effects on performance.

Turning to the impact of the banking sector's concentration, it is observed that the coefficient of the three bank concentration ratio (CR_3) exhibits a negative sign. However, it is worth noting that the coefficient of the variable is never significant in any of the regression models estimated. On the other hand, the empirical findings seem to suggest that the impact of stock market capitalization (MKTCAP/GDP) has a negative relationship with Thailand banks' TFPCH levels. If anything could be delved, the findings seem to suggest that during the period under study, the Thailand stock market serves as a complement rather than a substitute to borrowers in Thailand. It is observed from column 3 of Table 4 that the coefficient of the DUMCRIS variable is positive, but is not statistically significant at any conventional levels.

The results presented in column 4 of Table 4 indicate that the coefficient of DUMFORB is negative, but is not statistically significant at any conventional levels. Similarly, the coefficient of DUMGOVT is negative, but again is not statistically significant in the regression model estimated. During the period under study, the empirical findings seem to suggest that there is no significant advantage accrued to the publicly listed banks. The market discipline hypothesis implies that banks whose shares are publicly traded should exhibit higher efficiency, but the findings from this study seem to suggest that the Thailand capital market exerts no discipline over bank management.

Table 4: Panel Ordinary Least Square (OLS) Regression Analysis

$$\lambda_{jt} = \delta_0 + \beta_1 LLP/TL + \beta_2 NII/TA + \beta_3 NIE/TA + \beta_4 LOANS/TA + \beta_5 LNTA + \beta_6 EQASS + \beta_7 ROA + \zeta_8 LNGDP + \zeta_9 INFL + \zeta_{10} CR3 + \zeta_{11} MKTCAP/GDP + \zeta_{12} DUMCRIS + \delta_{13} DUMFORB + \delta_{14} DUMGOVT + \delta_{15} DUMPUBL + \varepsilon_j$$

The dependent variable is bank's technical efficiency score derived from the MPI method. LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans. NII/TA is a measure of bank's diversification towards non-interest income, calculated as total non-interest income divided by total assets. NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets. LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets. LNTA is the size of the bank's total asset measured as the natural logarithm of total bank assets. EQASS is a measure of banks capitalization measured by banks total shareholders' equity divided by total assets. ROA is return on assets calculated as profit after tax divided by total assets. LNGDP is natural logarithm of gross domestic product. INFL is the rate of inflation. CR3 is the three largest banks asset concentration ratio. MKTCAP/GDP is the ratio of stock market capitalization. The variable serves as a proxy of financial development. DUMCRIS is a dummy variable that takes a value of 1 for the crisis period, 0 otherwise. DUMFORB is a dummy variable that takes a value of 1 for foreign banks, 0 otherwise. DUMGOVT is a dummy variable that takes a value of 1 for government links banks, 0 otherwise. DUMPUBL is a dummy variable that takes a value of 1 for publicly listed banks, 0 otherwise.

Values in parentheses are *t*-statistics.

***, **, and * indicate significance at 1, 5 and 10% levels.

	(1)	(2)	(3)	(4)	(5)	(6)
CONSTANT	0.9787***	0.4748	3.5943**	3.5394**	3.4539**	3.4656*
	(6.1277)	(0.3069)	(1.9567)	(1.9680)	(1.9548)	(1.8744)
Bank Specific Characteristics						
LLP/TL	-0.0067	-0.0072	-0.0061**	-0.0051**	-0.0052**	-0.0050**
	(-0.9216)	(-1.5006)	(-2.0020)	(-2.0212)	(-2.1353)	(-2.1226)
NII/TA	-0.0619**	-0.0571*	-0.0753***	-0.0813***	-0.0847***	-0.0725***
	(-2.4116)	(-1.6921)	(-2.7376)	(-3.0313)	(-3.4512)	(-2.7174)
NIE/TA	0.0292**	0.0206	0.0310**	0.0302**	0.0298**	0.0261
	(1.9847)	(0.8560)	(2.1315)	(2.0041)	(1.9390)	(1.4550)
LOANS/TA	0.0003	0.0002	0.0005	0.0010	0.0011	0.0005
	(0.1773)	(0.1637)	(0.3412)	(0.5128)	(0.6297)	(0.3264)
LNTA	-0.0020	-0.0189	-0.0241	-0.0287	-0.0307	-0.0447
	(-0.0793)	(-0.5008)	(-0.5477)	(-0.5984)	(-0.6231)	(-0.7522)
EQASS	0.0075	0.0050	0.1289**	0.1298**	0.1317**	0.0363
	(0.7960)	(0.7253)	(2.1880)	(2.1725)	(2.0992)	(0.7663)
ROA	0.0256	0.0237	0.0331**	0.0323**	0.0317**	0.0259
	(1.2385)	(1.0014)	(2.2929)	(2.2078)	(2.0945)	(1.3887)
Economic and Market Conditions						
LNGDP		0.5151*	-0.4273	-0.4231	-0.4035	-0.4341
		(1.6435)	(-1.2795)	(-1.2776)	(-1.2261)	(-1.2714)
INFL		-0.1906**	-0.0925***	-0.0910***	-0.0932**	-0.0779**
		(-2.5682)	(-2.6194)	(-2.6075)	(-2.6123)	(-2.3049)
CR3		-4.1863	-1.5600	-1.4200	-1.4612	-0.9670
		(-1.2999)	(-1.0221)	(-0.9485)	(-0.9826)	(-0.6900)
MKTCAP/GDP		0.0101**	0.0113***	0.0112***	0.0112***	0.0108***
		(2.5590)	(2.9148)	(2.9230)	(2.9276)	(2.9314)
DUMCRIS			0.0727			
			(1.0549)			
Bank Ownership						

DUMFORB				-0.0257 (-0.6030)		
DUMGOVT					-0.0028 (-0.2391)	
DUMPUBL						0.0360 (1.4286)
No. of Obs.	154	154	154	154	154	154
R^2	0.0562	0.3181	0.3760	0.3729	0.3726	0.4500
Adj. R^2	0.0110	0.2653	0.3229	0.3195	0.3192	0.4032
D-W Statistics	2.7701	2.7380	1.9298	1.9583	1.9632	1.8602
F-Statistics	1.2431	6.0219***	7.0810***	6.9865***	6.9771***	9.6147***

4.3 Robustness Checks

In order to check for the robustness of the results, we have performed a number of sensitivity analyses. First, we repeat equation (11) by using the random effects model. The results are presented in Table 5. All in all, it can be observed from Table 5 that the coefficients of the baseline variables stay mostly the same: they keep the same sign, the same order of magnitude, they remain significant as they were so in the baseline regression models (albeit sometimes at different levels), and with few exceptions, do not become significant if they were not in the baseline regressions. Second, we restrict our sample to banks with more than three years of observations. All in all, the results remain qualitatively similar in terms of directions and significance levels. Finally, we address the effects of outliers in the sample by excluding the top and bottom 1% of the sample. The results continued to remain robust in terms of directions and significance levels. To conserve space, we do not report the regression results in the paper, but are available upon request.

5.0 CONCLUSIONS AND POLICY IMPLICATIONS

This paper attempts to examine the productivity of the Thailand banking sector during the post-Asian financial crisis period of 1999 to 2008. The productivity estimates are computed by using the Malmquist Productivity Index (MPI) method, which allows isolating efforts to catch up to the frontier (efficiency change) from shifts in the frontier (technological change). Also, the MPI enables us to explore the main sources of efficiency change: either improvements in management practices (pure technical efficiency change) or improvements towards optimal size (scale efficiency change).

The empirical findings from this study suggest that the Thailand banking sector has exhibited productivity regress during the period under study mainly due to technological regress rather than efficiency decline. The decomposition of the efficiency change index into its mutually exhaustive pure technical and scale efficiency components suggest that the increase in Thailand banks' efficiency was mainly attributed to the increase in pure technical efficiency. The results suggest that the domestic banks have exhibited productivity regress due to technological regress,

while the foreign banks have exhibited productivity progress mainly attributed to technological progress.

Table 5: Panel Random Effects Model (REM) Regression Analysis

$$\lambda_{jt} = \delta_0 + \beta_1 LLP/TL + \beta_2 NII/TA + \beta_3 NIE/TA + \beta_4 LOANS/TA + \beta_5 LNTA + \beta_6 EQASS + \beta_7 ROA + \zeta_8 LNGDP + \zeta_9 INFL + \zeta_{10} CR3 + \zeta_{11} MKTCAP/GDP + \zeta_{12} DUMCRIS + \delta_{13} DUMFORB + \delta_{14} DUMGOVT + \delta_{15} DUMPUBL + \varepsilon_j$$

The dependent variable is bank's technical efficiency score derived from the MPI method. LLP/TL is a measure of banks risk calculated as the ratio of total loan loss provisions divided by total loans. NII/TA is a measure of bank's diversification towards non-interest income, calculated as total non-interest income divided by total assets. NIE/TA is a measure of bank management quality calculated as total non-interest expenses divided by total assets. LOANS/TA is a measure of bank's loans intensity calculated as the ratio of total loans to bank total assets. LNTA is the size of the bank's total asset measured as the natural logarithm of total bank assets. EQASS is a measure of banks capitalization measured by banks total shareholders' equity divided by total assets. ROA is return on assets calculated as profit after tax divided by total assets. LNGDP is natural logarithm of gross domestic product. INFL is the rate of inflation. CR3 is the three largest banks asset concentration ratio. MKTCAP/GDP is the ratio of stock market capitalization. The variable serves as a proxy of financial development. DUMCRIS is a dummy variable that takes a value of 1 for the crisis period, 0 otherwise. DUMFORB is a dummy variable that takes a value of 1 for foreign banks, 0 otherwise. DUMGOVT is a dummy variable that takes a value of 1 for government links banks, 0 otherwise. DUMPUBL is a dummy variable that takes a value of 1 for publicly listed banks, 0 otherwise.

Values in parentheses are standard errors.

***, **, and * indicate significance at 1, 5 and 10% levels.

	(1)	(2)	(3)	(4)	(5)	(6)
CONSTANT	1.0750***	3.5076**	3.5967**	3.5394**	3.4539**	3.4656*
	(5.0423)	(1.9901)	(1.9582)	(1.9680)	(1.9548)	(1.8744)
Bank Specific Characteristics						
LLP/TL	-0.0021	-0.0052**	-0.0061**	-0.0051**	-0.0052**	-0.0050**
	(-1.2433)	(-2.0772)	(-2.0022)	(-2.0212)	(-2.1353)	(-2.1226)
NII/TA	-0.0587**	-0.0835***	-0.0753***	-0.0813***	-0.0847***	-0.0725***
	(-2.4583)	(-3.3690)	(-2.7351)	(-3.0313)	(-3.4512)	(-2.7174)
NIE/TA	0.0318**	0.0298**	0.0310**	0.0302**	0.0298**	0.0261
	(2.3058)	(1.9394)	(2.1288)	(2.0041)	(1.9390)	(1.4550)
LOANS/TA	0.0004	0.0011	0.0005	0.0010	0.0011	0.0005
	(0.2238)	(0.6277)	(0.3429)	(0.5128)	(0.6297)	(0.3264)
LNTA	-0.0277	-0.0300	-0.0240	-0.0287	-0.0307	-0.0447
	(-0.5916)	(-0.6387)	(-0.5440)	(-0.5984)	(-0.6231)	(-0.7522)
EQASS	0.0690	0.1300**	0.1289**	0.1298**	0.1317**	0.0363
	(0.7788)	(2.1981)	(2.1883)	(2.1725)	(2.0992)	(0.7663)
ROA	0.0344***	0.0319**	0.0331**	0.0323**	0.0317**	0.0259
	(2.7704)	(2.1520)	(2.2882)	(2.2078)	(2.0945)	(1.3887)
Economic and Market Conditions						
LNGDP		-0.4194	-0.4279	-0.4231	-0.4035	-0.4341
		(-1.2919)	(-1.2813)	(-1.2776)	(-1.2261)	(-1.2714)
INFL		-0.0917**	-0.0925***	-0.0910***	-0.0932***	-0.0779**
		(-2.5974)	(-2.6218)	(-2.6075)	(-2.6123)	(-2.3049)
CR3		-1.4285	-1.5602	-1.4200	-1.4612	-0.9670
		(-0.9515)	(-1.0233)	(-0.9485)	(-0.9826)	(-0.6900)

MKTCAP/GDP		0.0112***	0.0113***	0.0112***	0.0112***	0.0108***
		(2.9407)	(2.9149)	(2.9230)	(2.9276)	(2.9314)
DUMCRIS			0.0727			
			(1.0521)			
Bank Ownership						
DUMFORB				-0.0257		
				(-0.6030)		
DUMGOVT					-0.0028	
					(-0.2391)	
DUMPUBL						0.0360
						(1.4286)
No. of Obs.	154	154	154	154	154	154
R^2	0.1175	0.3724	0.3764	0.3729	0.3726	0.4500
Adj. R^2	0.0752	0.3238	0.3233	0.3195	0.3192	0.4032
D-W Statistics	1.5127	1.9607	1.9302	1.9583	1.9632	1.8602
F-Statistics	2.7781***	7.6613***	7.0923***	6.9865***	6.9771***	9.6147***

The panel regression analysis results indicate that most of the contextual variables have statistically significant impact on the productivity of Thailand banks. The empirical findings suggest that credit risk has negative impact on Thailand banks' total factor productivity levels. Likewise, the more diversified Thailand banks tend to be less productive. During the period under study, the findings indicate that overhead costs exert positive impact on the level of productivity of Thailand banks. The results also suggest that the relatively better capitalized Thailand banks tend to be more productive. Furthermore, banks that are more profitable also tend to be relatively productive.

Business cycle effects, display mixed impacts on bank total factor productivity. On the one hand, the results support the argument of the association between economic growth and the performance of the banking sector. On the other hand, the inflation has negatively impact on Thailand banks' total factor productivity indicating that the level of inflation is not fully anticipated by banks in Thailand. The impact of stock market capitalization is always positive, implying that the Thailand stock market serves as a complement rather than a substitute to borrowers in Thailand. During the period under study, the industry concentration of the national banking system has no significant impact. Similarly, the empirical findings seem to suggest that the influence of the recent global financial crisis is not significant on Thailand banks' total factor productivity.

The results from the panel regression analysis seem to suggest that there is no significant advantage accruing the foreign owned banks, while the government owned banks do not appear to be more productive. During the period under study, the results seem to indicate that there is no impact of stock exchange listings on Thailand banks' total factor productivity, implying that the Thailand capital market exerts no discipline over bank management.

The empirical findings from this study encompass considerable policy relevance. Firstly, in view of the increasing competition resulting from the more liberalized banking sector, the continued success of the Thailand banking sector

depends on its productivity, efficiency, and competitiveness. Therefore, bank managements as well as the policymakers will be more inclined to find ways to obtain the optimal utilization of capacities as well as making the best use of their resources, so that these resources are not wasted during the production of banking products and services. Thus, the policy direction will be directed towards enhancing the resilience, efficiency, and productivity of the banking sector with the aim of intensifying the robustness and stability of the financial system.

Secondly, the empirical findings from this study clearly suggest that scale efficiency has greater influence than pure technical efficiency in the domestic determining banks' efficiency levels. If anything could be delved, the small banks with its limited capabilities could well be at disadvantage compared to their large bank peers in terms of technological advancements. Therefore, from the policy making perspective, mergers, particularly among the small banking groups should be encouraged. This could entail the small banking groups to reap the benefits of economies of scale. The relatively larger institutions will also have better capability to invest in the state of the art technologies, which could further enhance the rate of total factor productivity growth of the Thailand banking sector. Moreover, consolidation among the small banking groups may also enable them to better withstand macroeconomic shocks like the Asian financial crisis.

Finally, the empirical findings from this study clearly bring forth the importance of technological change in determining the domestic and foreign banks' total factor productivity. The empirical findings from this study clearly demonstrate the superiority of the foreign owned banks in terms of technological advancements, which have generally overcome the home field advantage of the domestic banks. Therefore, constant technological upgrades and investments in the state of the art technologies should be an essential policy, particularly among the domestic banks in order to improve the rate of total factor productivity growth of the Thailand banking sector.

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