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MALMQUIST INDEX AND TECHNICAL EFFICIENCY OF PHILIPPINE COMMERCIAL BANKS IN THE POST-ASIAN FINANCIAL CRISIS PERIOD

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Following the Asian financial crisis in 1997, the Philippine banking system improved its productivity and efficiency. The paper examines the Malmquist index and technical efficiency scores of Philippine commercial banks for the post-crisis period employing data envelopment analysis (DEA) approach. Using a balanced panel of 35 banks, the time-varying Malmquist index shows that on average, banks improved their productivity by 4.6% annually from 1998 to 2005. Technological change or innovation dominated and offset the decay in the catch-up effect component of the index. The technological frontier shift of 110% for the 8-year period is largely driven by the innovation undertaken by banks to accommodate e-banking as well as build ATM and network infrastructure, in both in-site and off-site locations, with local banks outperforming the foreign banks in this aspect. Efficiency change or the catch-up component has been decreasing by 5.6% annually, suggesting that banks have been actually falling behind in management-influenced productivity rather than catching up. DEA results on technical efficiency show that majority of banks exhibit decreasing returns to scale. Universal banks are more technically efficient than plain commercial banks, providing evidence for scope economies.

I. INTRODUCTION

The global financial landscape has been changing rapidly in the last two decades. Market forces, due to or supported by regulatory changes and technological advances, have caused large changes in financial systems around the world (Rajan, 2005; Beck, 2006; Padoa-Schippoa, 2004). The Philippine banking sector did not escape these developments. There were three structural changes for the banking sector in the past decade: financial liberalization in 1994 with the passage of Republic Act No. 7721; the Asian financial crisis in 1997; and the wave of mergers and consolidation as a unique response to the crisis from 1998 up to the present. Because of these domestic structural changes coupled with worldwide financial innovation, it becomes imperative to measure the productivity and efficiency changes of Philippine commercial banks. If financial institutions operate more efficiently, they might improve profitability and allow greater amount of intermediated funds. Consequently, the consumer might expect better prices, service quality, and soundness of the financial system (Berger, Hunter & Timme, 1993). The rest of the paper is structured as follows. Section II revisits the Asian financial crisis with focus on the efficiency of the Philippine banking sector. Section III discusses the framework and hypotheses followed by presentation of method and data in section IV. Section V presents the results and Section VI concludes.

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II. ASIAN FINANCIAL CRISIS AND EFFICIENCY OF PHILIPPINE BANKS

The Asian financial crisis started with the Thai baht depreciation in July 2, 1997, followed by about 40% depreciation over a three-month period of the Philippine peso beginning July 11. Few local banks lending in US dollars to highly leveraged domestic corporations characterized the Asian crisis in the Philippines. Local companies took advantage of the relatively low interest rates on dollar-denominated loans, which were not hedged. When the peso depreciated, many corporate borrowers encountered cash flow problems and found it difficult to service their unhedged dollar-denominated debts, resulting in significant increases in non-performing loans. As banks increased their provision for loan losses, their capital-asset ratios deteriorated and available funds to support viable projects dwindled. Financial intermediation slowed down, causing economy-wide contraction in domestic output and rise in the unemployment rate. Despite these, the Philippines was the least affected by the 1997 crisis (Zhuang & Dowling, 2002), with only four distressed institutions—two banks and two nonbank financial institutions with only the latter closed (Bongini, Claessens & Ferri, 2000). According to Canlas (2000), only 23 banks failed in the Philippines by November 1998, and only one was a commercial bank, the rest were thrift and rural banks. These failed banks accounted for a small portion of the total banking resources, hence they did not pose serious threat to the financial system. For non-financial Philippine firms, the likelihood of filing for bankruptcy was lower for those with ownership links to banks and families. Claessens, Djankov and Klapper (1999) likewise confirmed that the Philippines reported the smallest number of bankruptcies during the crisis. According to Gochoco-Bautista and Reside (2000), the Philippine financial system managed to survive the Asian financial crisis due to two main factors. First, three years prior to the crisis, the BSP implemented improved prudential measures such as the imposition of increased capital requirements, tightening of provisioning requirements, and stricter loan classification subject to loan-loss provisioning. Second, the low level of financial intermediation in the Philippines, with a loan to GDP ratio of 65%, insulated the financial system from greater damage. The aftermath of the crisis saw the consolidation of the sector with BSP-encouraged mergers.

The efficiency of Philippine banks has been investigated either as in-country studies or cross-country comparisons. Laeven (1999) studied the risk and efficiency of banks in five East Asian countries including Philippines applying DEA for the pre-crisis period 1992-1996. The study pointed that for all five countries, bank efficiency did not decrease significantly. There was also a substantial increase in the efficiency of Philippine banks together with Indonesia and Thailand. Philippine and Indonesian banks took relatively more risk than banks from the other three countries. In terms of average technical efficiency scores, Philippine banks exhibited the second to the lowest—averaging 68% with 25% standard deviation (highest variability) for the study period 1992-1996. A two-factor fixed effects model for changes in efficiency showed that the coefficient of the year 1994-1995 is negative and significant for the Philippines, indicating a possible structural shift in the period due to foreign bank liberalization. Montinola and Moreno (2001) also employed DEA to examine indicators of efficiency in the Philippines over the period 1992-1999. Their study showed that banking efficiency in the production of deposits for the intermediation of loans declined prior to the liberalization of foreign bank entry. Further, there was no strong improvement in bank efficiency after liberalization. Modest efficiency improvements in 1995 suggested that foreign entry was too restrictive to generate a competitive environment to offset its adverse incentive effects. Manlagñit and Lamberte (2004), on the other hand, examined the impact of competition policy reforms on the efficiency of the Philippine commercial banking system from 1990 to 2002. Using stochastic frontier approach (SFA), they reported that Philippine banks have 85% average profit efficiency and 39% average cost inefficiency. Manlagñit and Lamberte (2004) also detailed improvements in banks' profit and cost efficiency after the liberalization in 1994 but such gains were halted when the crisis struck in 1997. In terms of bank size, the study noted that small banks are found to be more profit and cost efficient than large banks. Dacanay (2007) also examined the profit and cost efficiency of commercial banks in the Philippines from 1992 to 2004 using SFA. Results indicate that profit efficiency slowly decreased from a mean score of 92% in 1992 to 84% in 2004 while cost inefficiency hovered around 11% to 12% from 1992 to 1997, and then jumped to 14% to 15% from 1998 to 2004 in the post-crisis period. Efficiencies were found to be inversely related to asset size and off-balance sheet services were confirmed to be cost-absorbing, and substitute for traditional banking products. Karim (2001) studied bank efficiency across four ASEAN (Association of Southeast Asian Nations) countries for the period 1989 to 1996 and found that on average, the ASEAN banks enjoy increasing returns to scale. Karim (2001) included 27 sample banks from the Philippines, which were also the smallest in the group in terms of asset size. For cross-country comparison, the coefficient for the Philippines country dummy was positive. This implied that the inefficiency of input use for the Philippine banks tends to be higher than Indonesia, while that of Malaysia and Thailand are negative, indicating that the inefficiency of input use of both countries' banks tend to be smaller. The cost inefficiency of input use of Philippine banks averaged 34.16% for the 8-year period, compared with 18.18% for Indonesia, 4.35% for Malaysia, and 1.87% for Thailand. The cost inefficiency of input use of Philippine banks shot up to 69.5% in 1995, the year 10 new foreign banks entered the industry, but went down to 26.47% in 1996 or near the 1991 level of 25.81%. The results also showed that if the ASEAN banks were free to move within the ASEAN market, the Philippine and Indonesian banks would be at a disadvantage compared with their Thai and Malaysian counterparts. In contrast, Kwan (2003) noted that operating efficiency is found to be unrelated to the degree of openness of the banking sector, and in the case of the Philippines, the country is more open in practice than what the law demands (Claessens & Glaessner, 1998).

III. FRAMEWORK AND HYPOTHESIS

Malmquist Multifactor Productivity Index

The Malmquist index (MI) evaluates efficiency change over time. It is measured as the product of catch-up or recovery and frontier-shift or innovation terms, both coming from the DEA technologies. The concept of Malmquist productivity index, introduced by Malmquist (1953), has been studied and developed by Caves, Christensen and Diewert (1982), Färe and Grosskopf (1992), Färe, Grosskopt, Lindren and Roos (1989, 1994), Färe, Grosskopf and Russell (1998) and Thrall (2000). It is an index representing total factor productivity (TFP) growth of a bank or decision-making unit

(DMU). Since it is difficult to capture all the elements of TFP, the term multi-factor productivity (MFP) is used instead in this paper, reflecting progress or regress over time under the multiple inputs and multiple outputs framework.

The first component of MI, the catch-up effect, is determined by the efficiencies being measured by the distances from the respective frontiers and is given by Equation 1.

Equation 1:
$$C = \frac{\delta^t((x_0, y_0)^t)}{\delta^s((x_0, y_0)^s)}$$

The notation is as follows: *x* and *y* represent the input and output vectors, respectively. Catch-up effect does not allow for the inclusion of input prices, hence the score computed is technical and not allocative efficiency. The subscript $_0$ designates the DMU number; and, δ^s and δ^t represent the efficiency score for periods *s* and *t* frontier technologies, respectively. Hence, catch-up effect, C, is measured by the ratio of the efficiency of $(x_0,y_0)^t$ with respect to period *t* technological frontier and the efficiency of $(x_0,y_0)^s$ with respect to period *s* frontier. When C>1, it indicates progress in the relative efficiency from period *s* to *t*, while C=1 and C<1 indicate no change and regress in efficiency, respectively.

The catch-up effect is also termed as efficiency change or recovery in the literature. It can be further decomposed into its pure efficiency change (Pech) and scale efficiency change (Sech) components. On one hand, the pure efficiency change is relative to the variable return to scale (VRS) frontier and given by Equation 2. On the other hand, the scale efficiency change component is actually the geometric mean of two scale efficiency measures, given by Equation 3. The first is relative to the period *t* technology and the second is relative to period *s* technology. The extra subscripts *v* and *c* relate to the VRS and CRS (constant returns to scale) technologies, respectively.

Equation 2:
$$Pech = \frac{\delta_v^t(x_0, y_0)^t}{\delta_v^s(x_0, y_0)^s}$$

Equation 3:
$$Sech = \left[\frac{\delta_v^t(x_0, y_0)^t / \delta_c^t(x_0, y_0)^t}{\delta_v^t(x_0, y_0)^s / \delta_c^t(x_0, y_0)^s} \times \frac{\delta_v^s(x_0, y_0)^t / \delta_c^s(x_0, y_0)^t}{\delta_v^s(x_0, y_0)^s / \delta_c^s(x_0, y_0)^s}\right]^{1/2}$$

The second component of MI is the frontier-shift (innovation) effect or technological change. It is taken into account in order to fully evaluate the productivity change since the catch-up effect is determined by the efficiencies being measured by the distances from the respective frontiers. The frontier-shift effect is given by the formula:

Equation 4:
$$F = \left[\frac{\delta^s((x_0, y_0)^s)}{\delta^t((x_0, y_0)^s)} \times \frac{\delta^s((x_0, y_0)^t)}{\delta^t((x_0, y_0)^t)}\right]^{1/2}$$

The frontier-shift effect has in turn two components. The first component is the frontier-shift effect at $(x_0,y_0)^s$ evaluated as the ratio of efficiency of $(x_0,y_0)^s$ with respect to period *s* and *t* frontiers, respectively. The second component is the frontier-shift effect at $(x_0,y_0)^t$ evaluated as the ratio of efficiency of $(x_0,y_0)^t$ with respect to period *s* and *t* frontiers, respectively. Hence, frontier-shift effect is defined by the geometric mean of the two components. The frontier-shift effect F>1 indicates progress in the frontier technology around the DMU_0 from period *s* to *t*, while F=1 and F<1 indicate the status quo and regress in the frontier technology, respectively.

The product of the catch-up effect, C, and frontier shift effects, F, is the Malmquist index and is given by the formula:

Equation 5:

$$MI = \left[\frac{\delta^s((x_0, y_0)^t)}{\delta^s((x_0, y_0)^s)} \times \frac{\delta^t((x_0, y_0)^t)}{\delta^t((x_0, y_0)^s)} \right]^{1/2}$$

The expression in Equation 5 gives an interpretation of the geometric means of the two efficiency ratios: the first being the efficiency change measured by period *s* technology and the other the efficiency change measured by period *t* technology. As can be seen in Equation 5, MI consists of four terms: $\delta^s(x_0,y_0)^s$ and $\delta^t(x_0,y_0)^t$ in the main diagonal relate to the measurements within the same time period, while $\delta^s(x_0,y_0)^t$ and $\delta^t(x_0,y_0)^s$ in the off-diagonal account for intertemporal comparisons. MI>1 indicates progress in the multi-factor productivity of the DMU from period *s* to *t*, while MI=1 and MI<1 indicate the status quo and decay in the multi-factor productivity, respectively.

To calculate Equation 5, the four component distance functions are computed involving four linear programming (LP) problems. The LP of the upper left term is given by Equation 6.

Equation 6:

$$\left[\delta^s(x_0, y_0)^t\right]^{-1} = \max_{\phi,\lambda} \phi,$$

$$st$$

$$\begin{aligned} -\phi y_{it} + Y_s\lambda &\geq 0 \\ x_{it} - X_s\lambda &\geq 0 \\ \lambda &\geq 0 \end{aligned}$$

where Φ is a scalar and λ is a Ix1 vector of constants. The value of Φ obtained is the component score of the *i*-th firm. X and Y are input and output vectors, respectively, and the amounts of the i^{th} input consumed and output generated by the DMU_0, are denoted by *x* and *y* respectively. The indices *s* and *t* refer to the periods. The pattern for the other three LP problems corresponding to the other three terms in the MI equation is similar hence these were not shown here to conserve space. The calculation of the pure and scale efficiency components entail two additional LP problems with the convexity restriction N1'λ=1 [Nx1 vector of 1s] added to each of LPs of the upper right term for pure efficiency and lower left term of the MI for scale efficiency.

Technical Efficiency

Farrell's (1957) seminal paper lays the concept of economic efficiency measurement using an input orientation and discusses how it may be calculated relative to a given technology. Technology is generally represented by some form of a frontier function. The concept of efficiency can also be explained by an output-oriented measure (Färe, Grosskopf & Lovell, 1985). The input- and output-oriented measures are equivalent measures of technical efficiency when constant returns to scale exist. Farrell (1957) postulates that the efficiency of a firm consists of two components: 1) technical efficiency, which reflects the firm's ability to obtain maximum output from a given set of inputs; and, 2) allocative efficiency, which reflects the firm's ability to use the inputs in optimal proportions, given their respective prices and the production technology. The two measures are then combined to provide a measure of total economic efficiency.

Data envelopment analysis accounts for technical efficiency in using too many inputs (input orientation) or producing too few outputs (output orientation). Charnes, et al. (1978) assume CRS while Banker et al. (1984) assume VRS. This paper applies the input orientation because cost minimization or reduction is considered. The choice of VRS over CRS is justified on the grounds that not all banks are operating at an optimal scale due to imperfect competition, constraints on finance, among others. Equation 7 specifies the input-oriented VRS cost minimization LP problem.

Equation 7:

$$
\begin{aligned}
& Min_{\theta,\lambda}\theta \\
& st \\
& -y_i + Y\lambda \geq 0 \\
& \theta x_i - X\lambda \geq 0 \\
& N1'\lambda = 1 \\
& \lambda \geq 0
\end{aligned}
$$

where θ is a scalar and λ is a Ix1 vector of constants. The value of θ obtained is the inefficiency score of the *i*-th firm. X and Y are input and output vectors, respectively, and the amounts of the input consumed and output generated by the i^{th} bank, are denoted by x and y, respectively. As Coelli (1996) points out, the essential difference between the VRS and the CRS model is the addition of the constraint N1'λ=1 [Nx1 vector of 1s]. With this added constraint, the reference set is changed from a cone in the case of the CRS model to a convex hull in the case of the VRS model. One result of this change is that the tested DMU is compared against a limited number of combinations and as such, efficiency score is greater in the VRS compared to the CRS model.

Hypotheses

For the Malmquist multifactor productivity index and technical efficiency computations, the following hypotheses are tested:

H1a: There is difference in the Malmquist multifactor productivity indices between universal (expanded) and plain commercial banks.

Canals (1999) advances that universal banks offer two major types of cost advantage which could result in the positive evolution in efficiency over time: economies of scale and scope. In the Philippines, expanded (EKB) or non-expanded (NKB) commercial banking status can change. Banks can actually upgrade or downgrade their status from plain to universal bank or vice versa if they meet or fail to meet, respectively, the minimum capitalization requirements.

H1b: There is difference in the Malmquist multifactor productivity indices between domestic and foreign banks.

Barajas, et al. (2000) find that foreign banks are more productive than domestic banks though there are studies with conflicting conclusions. For example, Claessens, et al. (2000) find that foreign banks are more profitable than domestic banks in developed countries while it is the other way around in developing countries. Following the Asian financial crisis, this study posits that foreign-owned banks outperformed their domestic counterparts.

H2a: There are differences among increasing, constant and decreasing returns to scale technical efficiency scores.

The literature distinguishes efficient banks with qualitative characterizations as well as quantitative estimates. Efficient banks are those that exhibit constant returns to scale and the inefficient banks as those that show increasing and decreasing returns to scale (Banker et al., 2004).

H2b: There is difference between technical efficiency scores of expanded and plain commercial banks.

Similar to Hypothesis 1a, the difference between the technical efficiency scores of expanded and non-expanded commercial banks draws from the postulated scale and scope economies advantages of universal over plain commercial banks (Canals, 1999).

H2c: There is difference between technical efficiency scores of domestic and foreign banks.

Similar to Hypothesis 1b, this paper hypothesizes that foreign banks have higher technical efficiency scores than domestic banks.

H2d: There is difference between technical efficiency scores of the four old foreign banks and the new (or 'de novo') foreign banks.

The hypothesis is focused on the comparative technical efficiency scores of the old and new foreign banks sample following financial liberalization and the Asian financial crisis. It is conjectured that the new foreign banks which entered the industry after liberalization are not hampered by a legacy of relative inefficiency, hence in principle, should operate more closely to the efficient frontier (Canhoto & Dermine, 2003). The four old foreign banks—HSBC, Standard Chartered, Bank of America and Citibank—have been in existence prior to the General Banking Law in 1948 that barred the entry of foreign banks. After almost 50 years in 1995, the Philippines allowed the entry of 10 new foreign banks with a maximum of 6 bank branches each.

IV. METHOD AND DATA

Empirical Design for Efficiency Estimation

In their originating study, Charnes Cooper and Rhoades (1978) describe DEA as a 'mathematical programming model applied to observational data [that] provides a new way of obtaining empirical estimates of relations—such as the production functions and/or efficient production possibility surfaces'. DEA assumes that there are no random fluctuations, so that all deviations from the estimated frontier represent inefficiency. Luck or measurement error in an observation not on the estimated frontier is mistakenly included in that firm's measured efficiency relative to that part of frontier. The Malmquist index and technical efficiency scores are computed using the VRS model since commercial banks are not homogenous in terms of scale operations due to imperfect competition, constraints on finance, technology employed, among others. The nonparametric DEA is employed for the Malmquist index and technical efficiency score computations because as Färe, et al. (1994) suggest, if there is suitable panel data available, the distance measures of productivity changes can be calculated easily. Coelli's (1996) DEAP Version 2.1 is used to compute the Malmquist index and technical efficiency scores.

Banker (2004) constructs parametric and nonparametric tests enabling comparison between two groups of DMUs. For the efficiency change scores, since this paper maintains no assumptions on their probability distribution, a non-parametric Kolmogorov-Smirnov (K-S) test is applied. The K-S test statistic is given by the maximum vertical distance between $F^{G1}(ln(\theta_j))$ and $F^{G2}(ln(\theta_j))$, the empirical distributions of groups G_1 and G_2, respectively. The K-S test tries to determine if two datasets differ significantly, and the maximum difference between the cumulative distributions is given by the *D* statistic. The *D* statistic, by construction, takes values between 0 and 1 and a high value for this statistic is indicative of significant differences in efficiency between two groups.

After the computations in the first stage, regressions are employed in the second stage to test the potential correlates of the efficiency measures using Eviews software as a second stage approach. Following Dietsch and Lozano-Vivas (2000), the technical efficiency (TE) scores are regressed with the following exogenous variables: return on equity (ROE) as a measure of profitability; natural log of total assets (lnTA) as a proxy for bank size; ratio of off-balance sheet accounts to total assets (OBS/TA) as a measure of non-traditional banking services as more than two-thirds of bank services are no longer related to deposit-taking and loan-granting; the ratio of non-performing loans to total loan portfolio (NPL/TLP) as a measure of asset quality and risk; market share in terms of deposits (DEPMS) and loans (LOANMS) of individual banks as measures of competition and industry structure; the number of bank branches (BRA) as proxy for service quality and accessibility; dummy variable OWN =1 for foreign-owned, and 0 otherwise; and, dummy variable EKB=1 for expanded commercial banking status, and 0 otherwise.

Data

The dataset is constructed from the banks' published statements of condition filed with the BSP. Unlike in the other countries where Call Reports can be accessed by the general public, only individual bank's statements of condition are published by the BSP in its Factbook annually and quarterly in its website. Individual results of operations (income statements) are not available from the BSP but the aggregated data for the entire sector are.

The sample includes a balanced panel of 35 commercials banks from 1998 to 2005. Balances of contingent accounts are available starting 1998, a year after the Asian financial crisis, in part because of pressures for transparency due to corporate governance reforms. The 35 banks in the dataset include 13 out of 14 foreign bank branches, 2 out of 4 foreign bank subsidiaries, 18 out of 22 private domestic banks, and 2 out of 3 specialized government banks. The distribution of universal to plain commercial banking status is 14:21 in 1998 and has become 16:19 by 2005 due to the acquisition of expanded commercial banking license of HSBC in 1999 and of Standard Chartered Bank in 2001. The ratio of foreign to domestic banks in the sample is 15:20. The balanced panel of 35 banks accounts on average for 92.3%, 77.2% and 91.9% of total assets, deposits and loan base of the commercial banking system for the 1998 to 2005. The nominal amounts from the statements of condition are deflated using the CPI with 2000 as the base year. The other cross-section and industry-level variables are sourced from the BSP, Philippine Deposit Insurance Commission (PDIC) and the National Statistical Coordination Board (NSCB). The exclusion of banks that have incomplete information, or banks that failed over the study period possibly creates a sample selection and survivor bias which is a limitation of the study. Failed banks have been shown to be considerably less efficient on the average (Berger & Humphrey, 1992).

The period of eight years for the balanced panel data is sufficient to track productivity changes. If too short a period is chosen, random errors might not average out, in which case random error would be attributed to inefficiency. If too long a period is chosen, the firm's core efficiency becomes less meaningful because of changes in management and other events. DeYoung (1997) showed that a six-year time frame reasonably balanced these concerns. The eight-year period 1998 to 2005 dataset used to compute the Malmquist productivity index is sufficient to track productivity changes as the first year 1998 is used as a base, or reference year, hence only changes for the next seven years are reported. Furthermore, the period under study is considered post-Asian financial crisis, hence there were no other external shocks that could have potentially affected productivity.

Definition of Variables

For the computations, the study makes use of a multiple-input multiple-output model. The four output variables are: 1) contingent accounts; 2) net loans; 3) equity investments; and, 4) deposits. The two input variables are: 1) total fixed assets, and 2) equity capital. The first output variable contingent accounts represent off-balance sheet (OBS) activities. It includes unused commercial letters of credit, spot/ future exchange bought and sold, assets held in trust and investment management agreements, and others. By the end of 1998 and 2005, the proportion of contingent accounts representing OBS to total resources of the universal and commercial banking sectors is 62.09% and 65.44%, respectively. The General Banking Law of 1946 and its successor R.A. No. 8791 (General Banking Law of 2000) explicitly disallow the inclusion of securities and other properties held by banks in fiduciary or agency capacities in the statement of condition since these are not genuine resources of the company. The second output variable is net loans. It includes personal, commercial, corporate and other types of loans. Net loans represent the traditional banking service and traditional source of income for banks. The third output variable is equity investments. This output represents marketable securities and equity investments of banks in allied and non-allied businesses. The fourth output variable deposits include savings, time, demand and foreign-currency deposits. The first input variable total fixed assets is the net amount of bank premises, fixture and equipment. This represents the physical and fixed infrastructure of the banks required for bank operations. The other input variable equity capital or stockholders' equity represent the important capital input by the owners for the banks' production and intermediation process.

V. RESULTS AND DISCUSSION

The Malmquist multifactor productivity index improved by 36.3% for the eight-year period after the Asian financial crisis, with an annual average growth of 4.6% (geometric mean) as shown in Table 1. This positive change can be dichotomized into its catch-up and frontier-shift components. The catch-up or recovery component (efficiency change) registered 0.649 between 1998 and 2005, or below 1.00 indicating regress or negative efficiency change. On a year-by-year score, efficiency change only registered above the 1.0 mark for the 1999-2000 and 2001-2002 periods, or two years in the 8-year horizon. Multifactor productivity also significantly dropped to 94.6% in the period 2004-2005. The catch-up effect is comprised of pure and scale efficiency changes. Pure efficiency change represents core efficiency due to improved operations and management while scale efficiency change is associated with returns to scale effects. Both elements registered below 1.0 on average for the 8-year period suggesting regress in terms of operations and management, and negative scale economies effects. Technological change or frontier-shift represents the innovation in the banking system that has been developed, adapted or absorbed by the players. Technological change is 2.101 between 1998 and 2005, or more than a two-fold (110%) increase for the 8-year period. The average productivity growth (MI) of 4.6% annually is mainly due to the frontier shift or technological change that was brought about by massive innovations that occurred in that period, most notably the 40% improvement in technological change in the year 2000 to 2001. The E-commerce law was passed in June 2000 (RA 8793) and the BSP issued Circular No. 240 dated 05 May 2000 prescribing the guidelines on the provision of electronic banking services. In 2001, the BSP granted authority to 10 banks to engage in e-banking operations. By end of 2005, 33 banks have e-banking licenses. E-banking involved the range of online banking to wireless application protocol (WAP). Moreover, ATMs were transformed from mere 24-hour tellers to electronic terminals that allow consumers to transfer funds, pay bills, etc. ATMs have been around in the Philippines since the early 1980s. The number of ATMs of commercial banks in 1998 was 2,912 and by end of the study period in 2005, it has almost doubled to 5,606 machines. ATMs provided convenience to bank clients in malls, airports, schools and hospitals as 29% of all the ATMs in 2005 were located offsite.

Table 1
Malmquist Productivity Index of the Sample Banks

Year	Pure Efficiency Change (1)	Scale Efficiency Change (2)	Efficiency Change [Catch-up Effect] (3) = (1) x (2)	Technological Change [Frontier-shift] (4)	Multifactor Productivity Change (5) = (3) x (4)
1998-1999	1.016	0.933	0.948	1.062	1.006
1999-2000	1.018	1.101	1.120	1.046	1.172
2000-2001	0.948	0.803	0.761	1.407	1.071
2001-2002	1.020	1.089	1.111	0.923	1.026
2002-2003	0.978	0.990	0.968	1.066	1.032
2003-2004	1.054	0.888	0.936	1.160	1.085
2004-2005	0.941	0.848	0.798	1.186	0.946
1998-2005	0.969	0.669	0.649	2.101	1.363
Mean ($\overline{X}_G$)	0.996	0.944	0.940	1.113	1.046

The banks in the sample have been actually falling behind in management-influenced productivity rather than catching up. The catch-up component of the foreign banks' Malmquist index is higher than the domestic banks except for 2005. This suggests that foreign banks improved their management efficiency in the post-crisis period relative to the domestic banks. Ten new foreign banks entered the country in 1995 and by 1997 when the crisis struck, they had barely adjusted to the business environment. Since it was the domestic banks which were affected by the crisis and hence had to restructure, it was an opportune time for the foreign banks to catch-up. In terms of technological change, domestic banks fared better with an annual average improvement of 14.5%, double that of foreign banks' at 7.2% as shown in Table 2. Of the 33 banks with e-banking licenses in 2005, 20 are granted to domestic banks. Foreign banks's e-banking operations are mostly internet-based and proprietary while domestic banks' e-banking operations also include mobile- and landline-based banking as well as a wide network of onsite and offsite ATMs numbering 5,476 against foreign banks' 130 by end of 2005. This is consistent with the notion put forward by

Sensarma (2006) that foreign banks are not necessarily better in terms of technology compared to domestic banks.

Table 2
Malmquist Indices of Domestic and Foreign Banks

Year	Efficiency Change (1)	Technological Change (2)	Malmquist Index (3) = (1) x (2)
Domestic banks			
1998-1999	0.899	1.063	0.955
1999-2000	1.076	1.007	1.084
2000-2001	0.679	1.588	1.077
2001-2002	1.125	0.932	1.049
2002-2003	0.961	1.144	1.099
2003-2004	0.905	1.159	1.048
2004-2005	0.826	1.225	1.012
Mean ($\overline{X}_G$)	0.914	1.145	1.045
Foreign banks			
1998-1999	1.016	1.062	1.079
1999-2000	1.182	1.100	1.300
2000-2001	0.887	1.197	1.062
2001-2002	1.093	0.911	0.996
2002-2003	0.977	0.970	0.948
2003-2004	0.979	1.162	1.138
2004-2005	0.762	1.137	0.866
Mean ($\overline{X}_G$)	0.977	1.072	1.048

To test the first hypothesis whether there exists a difference between bank types, the sample is grouped according to universal (expanded) or plain commercial banks (Hypothesis 1a) and domestic- or foreign-owned (Hypothesis 1b). Expanded and plain commercial banks' Malmquist indices are not statistically different from each other but there is a significant difference between domestic and foreign banks. Table 3 presents the K-S test between domestic and foreign banks' Malmquist multifactor productivity scores and the components of the index. The null hypothesis of no difference among the component scores is rejected though the difference is weak, registering below 0.31. Though the geometric means of the indices are not far from each other (1.045 and 1.048), the differences actually lie in the two components of the index, which can be seen in the year-by-year changes between the two groups in Table 2. Both domestic and foreign banks registered efficiency change of less than 1.0, but the latter has higher mean score. The technological change mean score of 14.5% of domestic banks for the 8-year period is double that of foreign banks' 7.2%.

Table 3
K-S Comparison Test of Malmquist Indices of Domestic and Foreign Banks

	Cumulative Distribution Score	Null Hypothesis
Domestic (n_1=140) compared to Foreign banks (n_2=105)		
Malmquist index (MFP Change)	*D*=0.1833**	Reject
Catch-up effect (Recovery)	*D*=0.3071***	Reject
Frontier-shift (Innovation)	*D*=0.1857**	Reject
Pure efficiency change	*D*=0.1762**	Reject
Scale efficiency change	*D*=0.2976***	Reject

*** and ** indicate significance at $p<0.01$ and $p<0.05$, respectively.

The individual banks' Malmquist indices are given in Table 4. The top five banks out of the 35 in terms of MFP change for the 8-year period are: Deutsche and Banco de Oro, registering 23% MFP change; UCPB, 20%; Standard Chartered, 16%; and, Bangkok Bank, 15%. The laggards are: ICBC, Philtrust, DBP, ANZ and Citibank. It should be noted that 11 out of the 35 banks have MFP indices below 1.0, indicating regress, seven of which are domestic while four are foreign banks. The seven domestic banks with MI<1.0 indicating regress includes the two specialized government banks, DBP and LBP.

Table 4
Malmquist Indices for Individual Banks

No.	Name	Efficiency Change (1)	Technological Change (2)	Malmquist Index (3) = (1) x (2)
1	Allied Bank	0.948	1.208	1.145
2	ANZ	0.925	1.035	0.957
3	Asia United	1.055	1.090	1.150
4	Bangkok Bank	1.054	1.093	1.152
5	Bank of America	1.017	1.029	1.047
6	Banco de Oro	1.063	1.158	1.231
7	BDO Private Bank	0.862	1.135	0.979
8	Bank of Commerce	0.990	1.113	1.102
9	Bank of PI	0.848	1.143	0.969
10	Bank of Tokyo	1.000	1.065	1.065
11	China Bank	0.986	1.095	1.080
12	Chinatrust	0.986	1.044	1.046
13	Citibank	0.866	1.114	0.965
14	DBP	0.875	1.089	0.953
15	Deutsche	1.092	1.130	1.234
16	East West	0.958	1.077	1.033
17	Equitable PCI	0.868	1.213	1.054
18	HSBC	0.992	1.087	1.079
19	ICBC	0.774	1.043	0.807

No.	Name	Efficiency Change (1)	Technological Change (2)	Malmquist Index (3) = (1) x (2)
20	Ibank	0.921	1.070	0.985
21	ING	1.000	0.998	0.998
22	JP Morgan	0.948	1.143	1.083
23	Korea Exchange	0.941	1.108	1.042
24	LBP	0.840	1.166	0.979
25	Maybank	1.047	1.073	1.123
26	Metrobank	0.941	1.150	1.082
27	Mizuho	1.000	1.040	1.040
28	Philtrust	0.802	1.110	0.891
29	PNB	0.810	1.225	0.992
30	RCBC	0.925	1.196	1.106
31	Standard Chartered	1.062	1.094	1.161
32	Security	0.881	1.164	1.026
33	UCPB	1.001	1.195	1.197
34	Union	0.876	1.166	1.021
35	Philippine Veterans	0.874	1.146	1.002
	Mean	0.940	1.113	1.046
	Median	0.948	1.110	1.042
	Maximum	1.092	1.225	1.234
	Minimum	0.774	0.998	0.807
	Std. Deviation	0.083	0.057	0.092

The balanced panel dataset used in the calculation of Malmquist indices is also used to compute for the technical efficiency to determine the profile of the bank sample in terms of scale economies. The data are pooled generating 280 observations (35 banks times 8 years). The four output–two input model, similar to the Malmquist index model used, yields the following results: 22 observations exhibit constant returns to scale (CRS); 87 observations exhibit increasing returns to scale (IRS); and, 171 observations follow decreasing returns to scale (DRS). The literature distinguishes the efficient banks as those exhibiting constant returns to scale and the inefficient banks as those exhibiting the variable (increasing and decreasing) returns to scale. The model specification is able to discriminate between efficient and inefficient banks as only 22 out of the 280 observations, or 8% are within the efficient frontier. Paradi, Vela and Yang (2004) note that when 25% to 50% of the sample lie on the frontier, while it may not be a problem with the technique per se, it is a problem for management if it wishes to improve operations relative to other banks. Overall, the banks in the sample are, on average, 73.95% technically efficient. For the increasing and the decreasing returns (inefficient) groups to reach the level of the efficient group, they have to improve their efficiency level by 21% and 32%, respectively, on average. The results also indicate that the banks generally enjoy decreasing returns (171 out of 280 observations or 61.1 percent). In terms of the relationship of bank size as proxied by total assets or resources, smaller-sized banks with assets less than P35 billion in constant 2000 prices generally exhibit increasing returns to scale. Though there are overlaps, banks with assets up to P80 billion in constant prices are the most technically efficient banks (constant returns to scale). Large banks with an average size of P115 billion in constant prices exhibit decreasing returns to scale. This finding is consistent with Kaparis et al. (1994) which found that large banks generally exhibit decreasing returns to scale. Table 5 shows the technical efficiency scores for the full sample as well as for the different scale economy types and their corresponding asset sizes.

Table 5
Summary Statistics of Technical Efficiency Scores and Total Assets

	Technical Efficiency	Total Assets*
Full Sample (n=280)		
Mean	0.7395	75,854,748,768
Maximum	1.0000	406,076,036,761
Minimum	0.2110	112,222,835
Standard Deviation	0.2377	91,781,518,428
Constant Returns (n=22)		
Mean	0.9992	22,534,088,000
Maximum	1.0000	80,050,812,035
Minimum	0.9970	5,724,039,932
Standard Deviation	0.0010	17,401,726,986
Increasing Returns (n=87)		
Mean	0.7895	10,841,592,872
Maximum	0.9990	35,776,514,771
Minimum	0.2670	3,044,527,847
Standard Deviation	0.2036	6,204,245,502
Decreasing Returns (n=171)		
Mean	0.6806	115,791,580,697
Maximum	0.9970	406,076,036,761
Minimum	0.2110	122,222,838
Standard Deviation	0.2414	98,146,809,667

**in constant 2000 Philippine peso prices.*

The study tests the second hypothesis (Hypothesis 2a) whether the efficient group (constant returns) is different from the inefficient group (increasing and decreasing returns), and found the *D* statistic to be 0.9884 with a corresponding *p* value of 0.000, indicating a highly significant difference between the groups. To check for robustness, the study also tested the efficient group (CRS, n=22) against the two inefficient subgroups separately (IRS, n=87; and DRS, n=171), and found *D* statistics close to 1 with *p* values close to 0, indicating highly significant differences in the efficiency scores. The difference between the increasing and decreasing returns group, however, is weak, though statistically significant. The results are presented in the upper panel of Table 6.

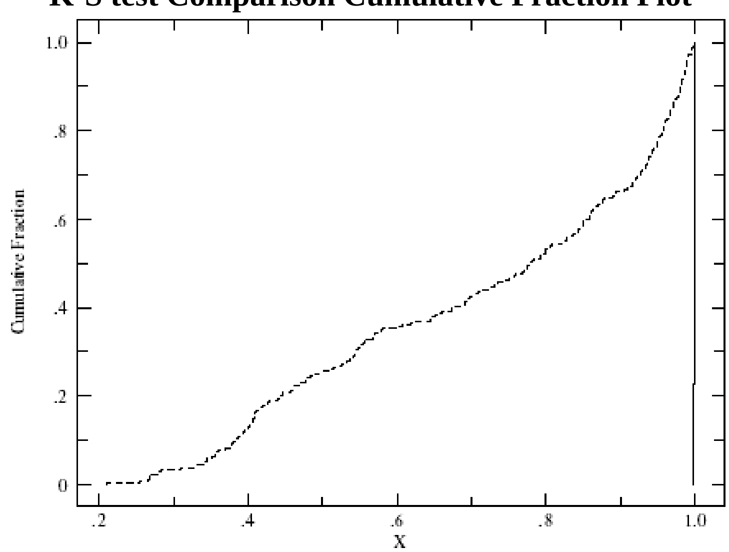
Table 6
K-S Comparison Test of Technical Efficiency Scores Across Scale Economies, Commercial Bank Type and Ownership

	Cumulative Distribution Score	Null Hypothesis
Scale economies: CRS (n_1= 22); IRS (n_2= 87); DRS (n_3= 171)		
CRS vs IRS and DRS	*D*=0.9884***	Reject
CRS vs IRS	*D*=0.9770***	Reject
CRS vs DRS	*D*=0.9942***	Reject
IRS vs DRS	*D*=0.2287***	Reject
Bank Type:		
EKB (n_1=156) vs NKB (n_2=124)	*D*=0.4293***	Reject
DB (n_1=160) vs FB (n_2=120)	*D*=0.2708***	Reject
Old FB (n_1=32) vs New FB (n_2=88)	*D*=0.3210**	Reject

**** and ** denote significance at 1% and 5% levels, respectively.*

The K-S test is a robust test that cares only about the relative distribution of the data, hence the value of the *D* statistic is not affected by scale changes. In Figure 1, the K-S percentile plot of the sets of efficiency scores is strikingly distinct. The efficient (CRS) scores plot are scrunched as a vertical line on the far right side of the graph while the inefficiency scores (IRS and DRS) appear as upwardly diagonal, indicating that on the whole, the efficiency scores are not likely to be normally nor log-normally distributed. Hence, the generality that the datasets are non-parametric and distribution free. The percentile plot is a better estimate of the distribution function and the probability scales allows for the inspection of how normal the data is. Normally distributed and log-normal data will plot as straight line on probability-scaled and probability-log scaled axes, respectively.

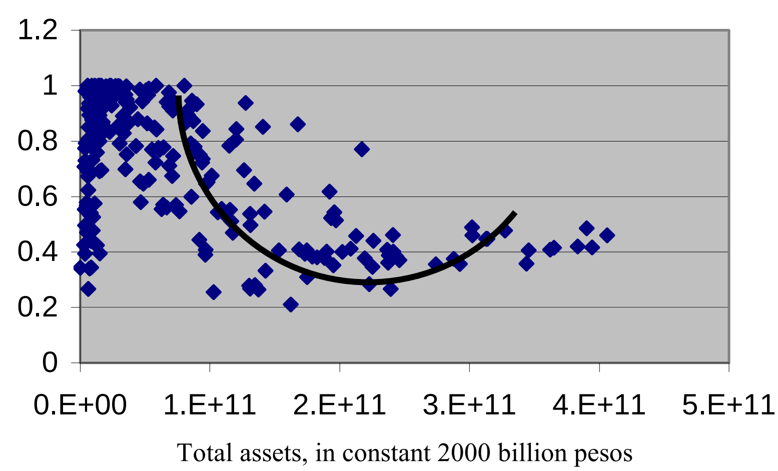
Figure 1
K-S test Comparison Cumulative Fraction Plot



The lower panel of Table 6 shows the final hypotheses tests. The comparison of technical efficiency scores (Hypothesis 2b) between expanded commercial (universal) banks (EKB) and non-expanded (plain) commercial banks (NKB) shows a medium strength but with a high statistical difference between the two types of banks. EKBs have a mean and median technical efficiency scores of 0.8369 and 0.9285, respectively, while NKBs have a mean and median technical scores of 0.6168 and 0.5580, respectively. For the pooled sample, the hypothesis test (Hypothesis 2c) finds that the 15 foreign-owned banks' mean technical efficiency score of 0.8183 is higher than and statistically different from the 20 domestically-owned banks' mean score of 0.6804. The 15 foreign banks are also grouped into 'old' or the original four foreign banks which had licenses to operate in the Philippines since the 1940s (Citibank, Standard Chartered Bank, Bank of America and HSBC) and the 'new' or the 11 *de novo* foreign banks that established their presence in the country as a result of the liberalization policy. The hypothesis test (Hypothesis 2d) finds that the *de novo* foreign banks have a statistically higher mean technical efficiency score of 0.8390 against the 'old' foreign banks with a mean technical efficiency score of 0.7611. A likely explanation for this phenomenon is that the old foreign banks may have become complacent due to their well-entrenched positions in the market ('quiet life' hypothesis).

To account for differential technical efficiency, bank characteristic variables are examined in relation to efficiency scores through regressions as a second stage procedure. The results of the regression show that asset size (lnTA) significantly and positively influences technical efficiency. The pair-wise correlation of lnTA with TE is negative, consistent with the empirical finding of inverse relationship between the two variables. Figure 2 shows the distribution of the TE scores with asset size. It can be seen that the CRS or efficient group (TE scores near 1.0) have small asset sizes while banks exhibiting decreasing returns are usually the ones with larger asset sizes. A U-shape relationship can be traced between TE scores and asset size.

Figure 2. Technical efficiency and asset size



The variables OBS/TA, LOANMS, and EKB are found to be inversely related to technical efficiency which can basically stem from size effects. Large banks have higher OBS/TA ratio or more extensive off-balance sheet operations; higher market share in the loans market, and; most likely have the license to engage in expanded commercial banking operations with required higher capitalization. The regression of technical efficiency score with correlates is given in Table 7.

Table 7
Regression of Technical Efficiency Scores with Potential Correlates

	Coefficient	t-ratio
Return on equity	5.52E-05	0.158
ln of total assets	0.03788	33.624***
Off-balance sheet accounts over total assets	-0.01552	-2.605***
Non-performing loan to total loan portfolio	3.06E-05	0.024
Market share, in terms of deposits	2.39201	1.674*
Market share, in terms of loans	-7.70218	-5.860***
Number of bank branches	-2.51E-05	-0.113
Ownership dummy, foreign-owned=1; 0 otherwise	0.01758	0.600
Universal bank=1; 0 for plain commercial banks	-0.84723	-2.829***
Adjusted R-squared	0.43528	
F-statistic	27.88157	

****, ** and * indicate significance at p<0.01, p<0.05 and p<0.10, respectively.*

VI. CONCLUSION

For time-varying efficiency, the Malmquist index shows that on average, banks improved their productivity by 4.6% annually from 1998 to 2005. Technological change or the innovation component dominated and offset the negative efficiency change or the catch-up effect component of the index. Technological change improved by 110% for the 1998 to 2005 period, driven by the massive innovation undertaken by banks to accommodate e-banking as well as build ATM and network infrastructure, both in-site and off-site locations, with local banks outperforming the foreign banks in this aspect. Efficiency change or the catch-up component has been decreasing by 5.6% annually, suggesting that banks have been actually falling behind in management-influenced productivity rather than catching up.

Results on scale economies from the technical efficiency computations indicate that, on average, Philippine commercial banks exhibit decreasing returns to scale. However, scale economies of banks exist up to an asset size of P80 billion in constant 2000 prices, but diseconomies of scale enter very rapidly thereafter. That is, the large banks have moved into the region of decreasing returns to scale. Expanded commercial banks are found to have significantly higher technical efficiency scores than ordinary commercial banks, providing evidence anew for scope economies. The old foreign banks are found to have lower mean technical efficiency scores than the new foreign banks. This is consistent with Canhoto and Dermine (2003) who posit that new banks are not saddled by a legacy of inefficiency.

The findings of the study point to the following implications. First, foreign banks are found to have higher technical efficiency scores than domestic banks, even if the former are handicapped by an uneven playing field. Foreign banks are only allowed up to six branches at most and their reach are limited to the corporate and the upper class market. The top domestic banks, on the other hand, have bank branches numbering more than 500 each. Opening the retail banking segment further to foreign banks would increase the competitive pressure on the industry improving efficiency. This is posited to have overall positive welfare effects. Second, plain commercial banks should be encouraged to upgrade themselves into universal or expanded commercial banks. The study finds that universal banks have significantly higher technical efficiency scores than ordinary commercial banks. The economies of scope that can be exploited from having an expanded commercial banking license should be a sufficient incentive for banks to upgrade. Medium- and small-sized non-expanded commercial banks should be encouraged to merge with large universal banks to exploit scale and scope economies. Third, the government should review its commercial banking operations. The two government banks, DBP and LBP, are shown to have regressed in terms of productivity in the post-crisis period with a Malmquist multifactor productivity index of less than 1.0. While the two government banks have specific socially relevant mandates, their venture into purely commercial banking services in part to subsidize their social mission is efficiency-depleting. There are opportunities for domestic banks, both private and government-owned, to improve productivity in the catching-up dimension. These policy prescriptions are hoped to make significant contribution to improve industry efficiency.

NOTES

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Appendix A
Dataset from the BSP-Published Banks' Statements of Condition

Year	1998	1999	2000	2001	2002	2003	2004	2005	Average
No. of banks	53	52	44	43	44	42	42	43	45.4
% Share of sample to									
Assets	74.6	87.6	94.0	94.6	95.1	95.8	98.2	98.4	92.3
Loans	71.8	71.2	80.4	79.0	81.1	77.4	79.8	77.1	77.2
Deposits	76.8	85.7	93.5	92.5	95.8	96.6	95.8	98.2	91.9

Appendix B
Descriptive Statistics of Variables Used in the Malmquist Index and Technical Efficiency Computations*

	Mean	Maximum	Minimum	Std. deviation
Contingent account (y_1)	4.79E+10	3.36E+11	2.43E+07	60,702,894,910
Loans (y_2)	3.17E+10	1.82E+11	3.44E+08	39,842,407,278
Equity investments (y_3)	2.02E+09	2.12E+10	0.00	4,266,904,749
Deposits (y_4)	5.04E+10	2.99E+11	3.88E+08	67,598,644,903
Capital account (x_1)	8.39E+09	5.12E+10	1.09E+08	11,839,208,502
Total fixed assets (x_2)	1.09E+09	1.48E+10	7.32E+05	3,227,291,746

**in constant 2000 Philippine pesos.*