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Estimating Philippine Bank Efficiencies Using Frontier Analysis

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Frontier method is used to estimate the 'best-performing frontier' to compute for the relative efficiencies of different bank groups (e.g., universal, commercial, thrift, rural and cooperative) in the Philippines over the period 1999-2009. As bank groups are used as decision-making units (DMUs), window analysis is utilized considering the few number of DMUs per period. Results from Data Envelopment Analysis (DEA), a non-parametric technique, indicate a generally declining trend in technical efficiency. Results also do not seem to fully support the hypothesis that bigger banks on the average are more efficient than smaller banks. Decomposing total factor productivity using the DEA-Malmquist TFP Index allows identification of sources of productivity and direction of its changes. Results indicate that Philippine banks have undergone technological progress but this did not necessarily increase total factor productivity because of the decline in technical efficiencies (TEs). These findings, however, cannot be conclusive because differences in efficiencies and changes in total factor productivity are not supported statistically. The researcher suggests the use of individual banks' data for each of the bank groups to possibly validate these results.

Keywords: bank efficiencies, Philippines, DEA

1 Introduction

Evaluating banks' performance is simply important. Today, banks face a very competitive market structure and yet continue to play a key role in the economic development and growth of a country given its primary function as financial intermediaries. Bank regulators use performance analyses of banks to determine how the industry will respond to new regulations and to aid in directing future government policies. Bank management also uses them because it is concerned about operations efficiency and profitability. Yet, selecting the most suitable assessment method remains a challenge among researchers (Paradi, Vela, & Yang, 2004).

Ratio analysis continues to be the standard technique used by regulators, industry analysts and management in examining bank performance. This is typically used to provide insights into banks' liquidity, profitability, capital adequacy, asset quality, and risk management among others. While simple, ratios cannot be reduced to a single measure that can cover the multi-faceted bank operations (Yue, 1992). There is also no clear basis that allows one to come up with a composite score on the overall financial soundness of a bank (Yeh, 1996). It also "offers no objective means of identifying inefficient units and requires a biased separation of the inefficient and efficient levels" (Paradi, Vela, & Yang, 2004, p. 351) rendering financial ratios inadequate.

Limitations of ratio analysis led to the development of more sophisticated tools for assessing bank performance (Paradi, Vela, & Yang, 2004). Parametric or nonparametric frontier analyses are used to measure relative efficiencies of production units based on their distances from the 'best practice' frontier. The frontier is empirically estimated from the data set since the true theoretical frontier is unknown. Parametic and nonparametric methods differ in the restrictions imposed on the functional form of the efficient frontier, the existence of random error and the distributional assumptions on the inefficiencies and random error (Bauer, 1990). Econometric or parametric analyses require an a priori specification of the form of the production function, and typically include two error components: an error term that captures inefficiency and a random error; mathematical or nonparametric methods require few assumptions when specifying the best practice frontier and they generally do not account for random errors (Paradi, Vela, & Yang, 2004). These methods are used to analyze countrywide banks or bank-branches, banks in different countries, and even bank mergers among others.

This study uses data envelopment analysis (DEA), a nonparametric approach, to evaluate the performance of Philippine banks. Current frontier studies on Philippine banks only use data on

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commercial banks. This study, on the other hand, looks at the Philippine banking system composed of universal, commercial, thrift, rural, and cooperative banks. While these banks differ in capitalization and in some products and services they offer[1], all perform the same intermediary function of taking in funds from depositors and lending to borrowers. Appendix 5 shows how these banks differ in scope of operations and capitalization requirements. Concerns about having too few decision-making units (DMUs) per period and/or too many output-input variables necessitate the use of window analysis suggested in DEA-bank related literature. DEA is used to compute for the relative efficiencies of each group over the period 1999-2009. Use of the DEA-Malmquist TFP productivity index provides additional information as to how efficiency, disaggregated into its different components, has changed during this period.

The BSP has so far been resolute in its quest to make banks more stable and equipped to face economic downturns especially since the Asian financial crisis in the late 1990s. Several policy moves implemented were clearly designed to do just that. With some incentives, mergers, acquisitions and consolidation were many in early 2000 making big banks even bigger. Capitalization of banks was also increased for all types of banks. Recently, incentives are dangled so mergers are further encouraged for rural banks. Apparently, the BSP believes that the Philippine economy is better off with bigger banks.

The BSP could be right in the direction it is taking. However, one may argue as well that smaller banks could perform just as well as the bigger banks— smaller banks may just be as efficient in terms of delivery according to its primary function as financial intermediaries. With this in mind, this study attempts to assess the different bank groups' efficiencies and productivity from an industry level grouping using available consolidated financial statements from the BSP. The availability of individual bank data for each of the groupings could provide additional information and insights in a future study.

The next section provides a review of some DEA studies including those that involve Philippine commercial banks, methods, and approaches to selection of input/output variables. Section 3 describes the methodology used to derive relative efficiencies and productivity change measures, as well as the data and hypotheses. Section 4 highlights and discusses the results. Conclusions and some future research directions are discussed in the final section.

2 Related Literature

Philippine Banking System Reforms

The financial crises over the past two decades are wake-up calls for most financial institutions to take less risky transactions and to operate more efficiently so that the BSP continues to carry-out financial reforms. Dacanay (2007) and Manlagñit (2011) outline these reforms in their review. In the 1980s, the government introduced major reforms (as changes in banking policies) to improve the Philippine financial system's efficiency in carrying-out its intermediary function and to withstand adverse shocks. In the 1990s, liberalization allowed foreign bank entry. In the aftermath of the Asian financial crisis, the minimum capitalization requirements for banks were increased. There were:

> …stricter requirements for granting new bank licenses and setting-up of new branches; tighter regulations on insider loans and on the restructuring of loans; redefinition of non-performing loans to align with international standards and introduction of general loan loss provisioning requirements; and higher specific provisioning for classified loans and expansion of bank disclosure requirements. (Manlagñit, 2011, p. 26).

In the 2000s, the General Banking Law was passed aimed at creating a globally competitive domestic banking system. Incentives are offered to encourage mergers, acquisition and consolidation. Banks' risk management capabilities are improved with the use of risk-based capital requirements and the development and implementation of internal credit risk rating system, among the other guidelines following Basel standards.

[1] Bangko Sentral ng Pilipinas' Circular No. 271 Series of 2001 identifies the significant differences in powers and scopes of authority of these banks. These dissimilarities, however, are not highlighted here considering the variables chosen for this study.

The bigger banks, however, are thought to have benefitted more than the smaller banks from the recent banking reforms. The incentives offered for banks to merge made it less costly for banks to become large while smaller banks, neither able to meet new capital requirements nor take advantage of merger incentives, opted to stay small (Manlagñit, 2001).

Bank Efficiency Studies and Methods Used

Berger and Humphrey (1997) showed in their survey of 130 frontier efficiency studies on banks (using different institution types, methodologies and data) that bank inefficiency is high and prevalent accounting for about 15%, on the average. These studies involved banks and bank branches in different countries as Belgium, Germany, Canada, Japan, Norway, Spain and the US among others. Several methods are utilized but DEA and stochastic frontier analysis (SFA) are the most frequently used.

Efficiency studies on financial institutions may be classified into three, according to Berger and Humphrey (1997): (1) those that provide information for government policy including the effects of deregulation, financial institution failure, market structure and mergers (see Lin, 2005; Dacanay, 2007; Moffat, Valadkhani, & Harvie, 2009; Manlagñit, 2011; Abbot, Wu, & Wang, 2011); (2) those concerned with research issues like the measurement of efficiency, comparisons of efficiency across international borders, issues of corporate control, risk and the stability over time of firm-level efficiency (see Weill, 2004; Ray, 2007; Hughes & Mester, 2008; Barry, Dacanay III, Lepetit, & Tarazi, 2010; Staub, da Silva e Sauza, & Tabak, 2010); and, (3) those associated with improving managerial performance including those in individual branches of the same firm (see Kwan & Eisenbeis, 1996; Athanassopoulos & Giokas, 2000; Dekker & Post, 2001; Portela, Thanassoulis, & Simpson, 2004; Paradi, Rouatt & Zhu, 2011).

A few frontier studies are known to have used Philippine data and all involve commercial and universal banks. Montinola and Moreno (2001), using DEA, found that the average efficiency of banks declined during 1992-1999. They attributed this decline in efficiency prior to foreign bank entry in 1994 as the adverse effect on performance due to lack of competition. Dacanay (2007), in examining profit and cost efficiencies of banks using SFA, found that cost efficiency declined in the years that followed the Asian financial crisis. He finds efficiencies to be inversely related to asset size: bigger (universal) banks show higher profit efficiency than smaller (commercial) banks. Also using SFA, Manlagñit (2011) found substantial and persistent inefficiencies averaging 25% of total costs among banks. She added that cost inefficiency decreases with bank size and attributes this to the likely advantage of bigger banks when it comes to adopting BSP's regulatory reforms. These reforms and extensive banks' expansion brought by increased competition are thought to have "increased banks' cost of capital", contributing to the worsening cost efficiency. Results also indicate that universal banks are more cost inefficient than ordinary commercial banks. She concludes that commercial banks are still operating sub-optimally and face potentially "significant improvements in cost efficiency" (Manlagñit, 2011, p. 33). Cross-country studies of bank efficiency on selected members of the Association of Southeast Asian Nations (ASEAN) consistently show that Philippine banks are among the most cost inefficient (Karim, 2001; Barry, et al., 2010).

In other countries, Sensarma (2005), in her study of Indian banks, found cost inefficiency declining over time due to the lower cost of financial intermediation brought about by the "increased competitive pressure and entry of new banks in the industry" (p. 1205). She also finds that bigger banks are less cost efficient than their smaller counterparts as "bigger banks may be difficult to manage, staff motivation may be low, labour relations may not be ideal and the large branch network may be costly to maintain" (Sensarma, 2005, p. 1205). The same findings are found in Greek banks (Christopoulos, Lolos, & Tsionas, 2002). In Malaysia, Krishnasamy, Ridswa, and Perumal (2004) found that size alone does not guarantee efficiency with regard to economies of scale and success. They add that technological change rather than improvements in pure technical efficiency or scale efficiency cause productivity change. Berger, Hunter, and Timme (1993) also found that medium-sized banks are slightly more scale efficient than large banks that continued to experience post-merger problems. Being small is not necessarily bad as Lin (2005) found smaller banks performing better than larger banks in Taiwan.

While most efficiency studies involve only a specific type of bank, there are also studies[2] that look at the efficiencies of different bank types from an industry point of view. This means that a common frontier is estimated for all banks in the system assuming that these banks perform the same intermediary function. This study makes use of the same assumption. In Altunbas, Evans, & Molyneux (2001), separate frontiers are estimated for private commercial, public (government-owned) savings, and mutual cooperative banks in Germany[3]. They assert, however, that the same technology of intermediation is available to all so that efficiency should be compared among all types of forms thereby estimating a common frontier. Among their findings are: (1) the private sector tends to be less profit and cost efficient than the other two sectors; (2) private, public and mutual banks benefit from widespread economies of scale; and (3) technological progress makes an important contribution to cost reduction in the German banking system (Altunbas, Evans, & Molyneux, 2001). Fiorentino, Karmann, and Koetter (2006) highlighted the need to compare all banks to a common frontier "to obtain a holistic picture of the relative performance in the industry as a whole" (p. 9) in their study of the German banking system[4]. Staub, da Silva e Souza, and Tabak (2010), as well as and Maudos, Pastor, & Perez (2002), also estimate an industry frontier on the assumption that the banks perform the same intermediary function having deposits and credit operations. They also highlighted, however, the importance of looking at individual frontiers per bank type. Staub, da Silva e Souza, and Tabak (2010) found, among others, the Brazilian banking system to be highly inefficient and, while small banks appear to be more efficient, size is not statistically significant suggesting no substantial differences in banks pursuing different bank activities[5]. Maudos, Pastor, & Perez (2002), on the other hand, showed how a common frontier could bias individual banks' efficiencies in the Spanish banking sector. They found the cost efficiency for the whole banking system to be about 70%, compared to around 90% when considering the existence of different product ranges[6].

Approaches to Identification of Output-Input Variables

There is no consensus as to how output and input variables are to be identified as appropriate for use in bank efficiency studies. While there are common approaches, it does not even mean that they use the same variables. Also, financial services created by the banking industry are usually assumed to be proportional to the monetary values of assets and liabilities (Adams, Berger, & Sickles, 1999).

In Camanho and Dyson's (2005) survey, the two main approaches that reflect the different perspectives of banking activity are the (1) production and (2) intermediation approaches. Most of the bank efficiency studies in the past used the production approach in their choice of output and input variables. It emphasizes the operational activity and banks are primarily viewed as providers of service to customers. Inputs "only include physical variables (e.g. labor, materials, space or information systems) or their associated costs, since only physical inputs are needed to perform transactions, process financial documents or provide counseling and advisory services to customers. Interest costs are excluded from this approach on the grounds that only the operational process is of interest" (Camacho & Dyson, 2005, p. 486). Outputs include services provided to customers and is "best measured by the number and type of transactions dealt with, documents processed, or specialized services provided over a given time period. When detailed transaction flow data are not

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[2] These studies use individual banks' data for each of the bank groups to create a large pool of DMUs and none needed to use window analysis.

[3] A description of these types of banks, provided on pp. 13-16 of the article, show some similarities in scope of authority to Philippine banks: private commercial to UBs & KBs; public savings to TBs & RBs; and, mutual cooperative banks to CBs. These German banks also differ in size where the mean total assets (in USD million) is 10,417.0, 1,531.0 and 471.0 for private commercial, public savings and mutual cooperative banks, respectively.

[4] Banks are classified into commercial, savings (central & regional) and cooperatives (central & regional). The mean volume for commercial loans in million Euros (€) are: 4,380 for commercial, 35,300 for savings central, 891 for savings regional, 11,100 for cooperatives central and 144 for cooperatives regional. Fixed assets, in million Euros (€), are 36, 151, 23, 108 and 4, respectively.

[5] Brazilian banks are classified into large, medium, small, and micro.

[6] Spanish banks are classified into universal banks, small banks, regional/savings banks, and foreign banks.

available, data on the stock of deposit and loan accounts are often used instead, as a proxy for the level of services provided" (Camacho & Dyson, 2005, p. 486). Under the intermediation approach, financial institutions are viewed as primarily intermediating funds between savers and investors:

> Banks produce intermediation services through the collection of deposits and other liabilities and their application in interest earning assets, such as loans, securities and other investments. This approach includes both operating and interest expenses as inputs, whereas loans and other major assets of financial institutions count as outputs. (Camacho & Dyson, 2005, p. 486).

Researchers, however view deposits differently as it may be counted as inputs or outputs. Debate on the identification of output led to the establishment of the asset, user cost and value added approaches, considered as variants of the intermediation approach discussed in Camanho and Dyson (2005).

3 Methodology, Data & Hypotheses

Frontier analysis is a tool used to benchmark and rank the relative performance of production units like banks. It allows one to "assign numerical efficiency values, broadly identify areas of input overuse and/or output underproduction and relate these results to questions of government policy or academic research interest" (Berger & Humphrey, 1997, p. 1). Frontier efficiency studies involving financial institutions rely on financial statements or on accounting measures of costs, outputs, inputs, revenues, profits, and so on, to impute efficiency relative to the best practice within the available sample.

In their survey, Berger & Humphrey (1997) found that at least five different approaches[7] have been employed when evaluating the performance of financial institutions and its branches. These differ primarily in the assumptions about the shape of the frontier and distribution imposed on the random error and inefficiency. These are also generally classified as either nonparametric or parametric approaches. Nonparametric approaches, such as DEA and free disposal hull (FDH), put relatively little or no structure on the specification of the best-practice frontier. "Either approach permits efficiency to vary over time and make no prior assumption regarding the form of the distribution of inefficiencies across observations except that undominated observations are 100% efficient" (Berger & Humphrey, 1997, p. 5). A key shortcoming of nonparametric approaches is on the assumption that there is no random error and this is taken to mean that there is:

> (a) no measurement error in the construction of the frontier; (b) no luck that temporarily gives a decision making unit better measured performance on year from the next; and, (c) no inaccuracies created by accounting rules that would make measured outputs and inputs deviate from economic outputs and inputs. (Berger & Humprey, 1997, p. 6).

Parametric approaches, on the other hand, assume some functional form of the best-practice frontier and presence of random error. These include the stochastic frontier approach (SFA), which is also called econometric frontier approach, the distribution free approach (DFA), and the thick frontier approach (TFA).

There is no consensus as to the preferred method in determining the best-practice frontier against which relative efficiencies are measured (Berger & Humphrey, 1997). This current lack of agreement "boils down to a difference of opinion regarding the lesser of evils" (Berger & Humphrey, 1997, p. 8). Parametric approaches face the danger of misspecification as these impose a particular functional form of the frontier, while nonparametric approaches assumes non-existence of random error arising from luck, data problems, or other measurement errors. As it is not possible to determine which approach dominates the other, Berger and Humphrey (1997) suggest looking at "adding more flexibility to the parametric approaches and introducing a degree of random error into nonparametric approaches" (p. 9) now used in some studies[8].

Discussions and notations in the succeeding sub-sections are drawn from the works of Coelli, Rao, O'Donnell, & Battese (2005) and Cooper, Seiford, and Tone (2007). Additional information derived from other sources are cited correspondingly.

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[7] See Berger & Humphrey (1997), Coelli et al. (2005), and Cooper, Seiford, & Tone (2007) for detailed description of each of these approaches.

[8] See Berger & Humphrey (1997) for a survey of some of these studies.

3.1 Concepts in Efficiency and Productivity Analysis

The efficiency concept. The efficiency of a firm that utilizes a single input and produces a single output is expressed as $Efficiency = output/input$[9]. This measure refers to technical efficiency (TE) that reflects the ability of a firm to obtain optimum output from a given set of inputs or, conversely, the ability of a firm to utilize the least input to produce specific amounts of outputs. Where input price data are available, allocative efficiency (AE) reflects the ability of a firm to use inputs in optimal proportions. These two efficiency measures combined ($TE \times AE = CE$) provide a measure of the cost efficiency of the firm. All three efficiency measures are bounded by zero and one. A value of one implies that the firm is fully efficient.

CRS, VRS and scale efficiency. Charnes, Cooper & Rhodes' (1978) proposed model had an input orientation and assumed constant returns to scale (CRS). CRS means that the producers are able to linearly scale the inputs and outputs without increasing or decreasing efficiency. Such assumption, however, may only be valid over a limited range and it implies that "bank size does not matter for productivity" (Dogan & Fausten, 2003, p. 14). Considering trends towards increasing concentration in the industry, such assumption may not hold and, therefore, studies on bank efficiency should allow for the existence of variable returns to scale or VRS (Dogan & Fausten, 2003).

A CRS assumption is valid when all firms are operating at an optimal scale. Otherwise, the VRS is appropriate. In such a state, a firm may be too small or too large in its scale of operation. In both of these cases, efficiency of the firms might be improved by changing their scale of operations (i.e., keep the same input mix but change the size of operation). If the underlying production technology is a globally constant returns to scale (CRS) technology then the firm is automatically efficient. CRS tends to lower the efficiency scores while VRS tends to raise efficiency scores. Where a CRS and a VRS DEA is conducted and there is a difference in the two technical efficiency (TE) scores, one may be able to decompose the TE into two components: one due to scale inefficiency (SE) and another due to "pure" technical inefficiency. The SE is the difference between the CRS TE and VRS TE and refers to the extent to which the firm can take advantage of returns to scale by altering its size towards the optimal scale.

This study assumes a VRS technology and, therefore, also assumes that banks do not necessarily operate at an optimal scale.

Malmquist TFP index and decomposition of productivity change. Productivity and productivity change measures provide information as to how production units perform. The former compares performance of firms at a given point in time while the latter refers to movements in productivity performance of a firm or an industry over time.

Several approaches have been advanced to derive meaningful measures of productivity changes. This study uses the approach advocated in Caves, Christensen, and Diewert (1982). Labeled as the CCD approach, it measures productivity by comparing the observed outputs in period s and t with the maximum level of outputs (i.e., keeping the output mix constant) that can be produced using X_s and X_t operating under the reference technology. CCD defined the total factor productivity (TFP) index using Malmquist input and output distance functions, and thus the resulting index has come to be known as the Malmquist TFP index. It has since become a commonly used measure of productivity change in literature. As the distances can be either output oriented or input oriented, the Malmquist TFP indices differ according to the orientation used.

Fare, Grosskopf, and Roos (1998) show how the Malmquist TFP index could be decomposed into pure efficiency, technical and scale efficiency changes. For the Malmquist index, values greater than one indicate an improvement in productivity, while values less than one mean indicate deterioration in productivity. The same interpretation applies to its decomposed indices but there is no presumption that these indices must always move in the same direction (Dogan & Fausten, 2003). Among the different methods used to estimate a production technology, the most popular method is the DEA-like linear programming methods suggested by Fare et al. (1994).

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[9] $Efficiency = (\sum Weighted\ Outputs)/(\sum Weighted\ Inputs)$ for a firm that uses multiple inputs and outputs. Weights are either fixed in advance or derived from the data. The former is also referred to as an a priori determination (Cooper, Seiford, & Tone, 2007).

3.2 Data Envelopment Analysis (DEA)

DEA uses linear programming methods to construct a non-parametric piece-wise surface (or frontier) over the data. Efficiency measures are then calculated relative to this surface. While the method was introduced in the 1950s, it gained attention and popularity among researchers only after Charnes, Cooper, and Rhodes (CCR) came out with their paper in 1978. The CCR model has an input orientation and assumes constant returns to scale (CRS). Subsequent papers, as those of Banker, Charnes, and Cooper (BBC) (1984), alternatively used a variable returns to scale (VRS) assumption. Their BCC model[10], as it came to be known, uses the following mathematical programming problem in DEA:

$$\begin{aligned} &max_{\mu,v}(\mu' q_i) \\ &s.t. v'x_i = 1 \\ &\mu' q_j - v'x_j \leq 0, j = 1,2, \dots, I \\ &\mu, v \geq 0 \end{aligned} \tag{1}$$

Assume that there are data on N inputs and M outputs for each of I firms. For the i^{th} firm, these are represented by the column vectors x_i and q_i, respectively. The $N \times 1$ input matrix, X, and the $M \times 1, Q$, represent the data for all I firms, also referred to as DMUs in frontier literature. The μ is an $M \times 1$ vector of output weights, while v is an $N \times 1$ vector of input weights. For each firm, we would like to obtain a measure of the ratio of all outputs over all inputs, such as $\mu' q_i / v' x_i$. The optimal weights are obtained by finding values for u and v such that the efficiency measure for the i^{th} firm is maximized, subject to the constraints that all efficiency measures must be less than or equal to one. Duality in linear programming allows one to derive an equivalent envelopment form of this problem to

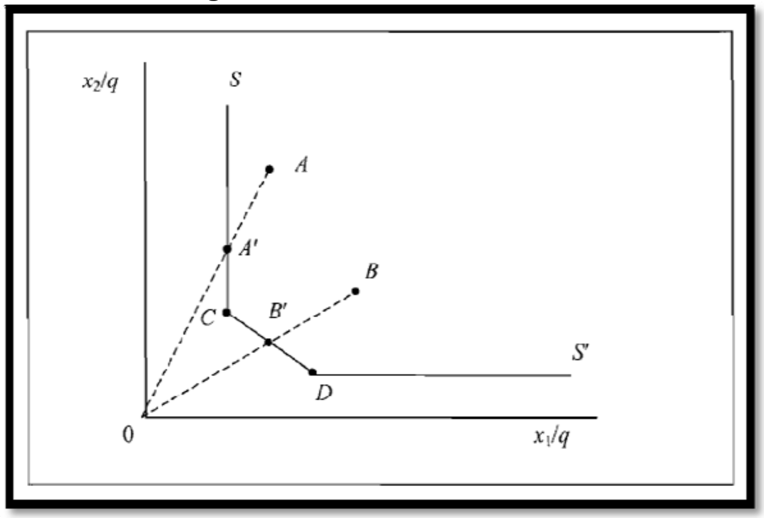
$$\begin{aligned} &min_{\theta,\lambda}\theta \\ &s.t. -q_i + Q\lambda \geq 0 \\ &\theta x_i - X\lambda \geq 0 \\ &I1'\lambda = 1 \\ &\lambda \geq 0 \end{aligned} \tag{2}$$

where θ is a scalar and λ is an $I \times 1$ vector of constants, whose value is the efficiency score for the i^{th} firm. It satisfies: $\theta \leq 1$, with a value of 1 indicating a point on the frontier and, hence, a technically efficient firm, according to the Farrell (1957) definition. $I1$ is an $I \times 1$ vector of ones. This approach forms a convex hull of intersecting planes that envelope the data points more tightly than the CRS conical hull and, thus, provides technical efficiency scores that are greater than or equal to those obtained using the CRS model. The convexity constraint, $I1'\lambda = 1$, ensures that an inefficient firm is only benchmarked against firms of similar size. That is, the projected point (for that firm) on the DEA frontier is a convex combination of observed firms.

The problem takes the i^{th} firm and radially contracts the input vector, x_i, as much as possible, while still remaining within the feasible input set. The inner boundary of this set is a piece-wise linear isoquant determined by the observed data points as shown in Figure 4 below.

[10] The mathematical programming problem of the CCR model in DEA is the same with the BCC model with the exception of the convexity constraint, (Coelli et al., 2005).

Figure 4. Efficient Frontier with DEA



Note. Adopted from Coelli et al., 2005, p. 165.

The radial contraction of the input vector, x_i, produces a projected point, $(X\lambda, Q\lambda)$, on the surface of this technology. This projected point is a linear combination of these observed data points. The constraints ensure that this projected point cannot lie outside the feasible set[11]. The DEA efficiency score for a specific decision making unit (DMU), hence, is not defined by an absolute standard but is measured with respect to empirically constructed efficient frontier by the best performing DMUs.

In input-oriented models, the method identifies technical inefficiency as a proportional reduction in input usage, with output levels held constant. It is also possible to measure technical inefficiency as a proportional increase in output production, with input levels held fixed, using an output orientation. The two measures provide the same value under CRS but are unequal when VRS is assumed. Given that linear programming does not suffer from such statistical problems as simultaneous equations bias, the choice of an appropriate orientation[12] is not as crucial as it is in the case of econometric estimation.

Among the few limitations and possible problems that a researcher may encounter in conducting a DEA study outlined in Coelli et al. (2005), perhaps of most concern for this study is the use of few observations and having many inputs and/or outputs that could result in having many firms appearing on the DEA frontier. On the frontier, all these firms will have a technical efficiency of 1.0, which makes it difficult to discriminate from one production unit to another. While it is ideal to use individual banks' data in each of the bank groups for this study, only consolidated financial statements (Statements of Income & Expenses and Statements of Condition) per bank group are made available to the public by the BSP in their website.

DEA-Window analysis. Many DEA studies involve several DMUs in their analyses. There are those, however, that use only a few DMUs such those of Yeh (1996), Paradi, Asmild, Aggarwall, & Schaffnit, (n.d.), and Abbot, Wu and Wang (2011). The use of only five DMUs is considered few in DEA literature especially when there is a need to use many inputs and outputs. Dogan and Fausten (2003) in their review of literature found some rules of thumb for acceptable sample size: (1) should

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11 As described in Fare, Grosskopf, Norris, & Zhang (1994), the production technology associated with the linear programming problem can be defined as . Fare et al. (1994) show that this technology defines a production set that is closed and convex, and exhibits constant returns to scale and strong disposability (Coelli et al., 2005).

12 Coelli et al. (2005) suggest selecting the orientation according to which quantities (inputs or outputs) the managers have most control over. Both output- and input-oriented DEA models will estimate exactly the same frontier and therefore, by definition, identify the same set of firms as being efficient. It is only the efficiency measures associated with the inefficient firms that may differ between the two methods.

be larger than the product of the number of inputs and number of outputs; and (2) should be at least three times as large as the sum of the number of inputs and the number of inputs.

Given that there are only five bank groups in the Philippine banking system, this study uses DEA Window Analysis, a technique that works on the principle of moving averages (Yue, 1992; Paradi et al., n.d.) and is useful in detecting performance trends of a unit over time. Each unit in a different period is treated as if it were a different unit. Hence, one can compare a unit's performance in a particular year with its own performance over the other periods and with the performance of other units (Paradi, Vela, & Yang, 2004). "Through a sequence of such "windows", the sensitivity of a firm's efficiency score can be derived for a particular year according to the changing conditions and a changing set of reference firms" (Yue, 1992, p. 35). A firm that is DEA efficient in a given year, regardless of the window, is likely to be truly efficient relative to other firms. Conversely, a firm that is only DEA efficient in a particular window may be efficient solely because of extraneous circumstances (Yue, 1992).

This study uses an input oriented model assuming that bank management has more control over its inputs than outputs (Coelli et al., 2005). In line with traditional window analysis[13], this study uses a six-year window to allow estimation of efficiencies for 30 "different" DMUs for each window. The average efficiency is computed based on the efficiencies of a particular DMU from "windows" where it is included. This "averaging" procedure is also used to derive average Malmquist indices (and its decompositions) for each of the DMUs in the different "windows". The computer program DEAP Version 2.1[14] written by Tim Coelli is used to construct DEA frontiers for the calculation of technical efficiencies and for the calculation of Malmquist TFP Indices.

3.3 Data

The study uses the financial statements available from the BSP website (www.bsp.gov.ph). Available for comparison are Consolidated Statements of Income & Expenses and Consolidated Statements of Condition for each of the bank groups – universal (UBs), commercial (KBs), thrift (TBs), rural (RBs), and cooperative banks (CBs) – for 1999-2009[15].

Following the intermediary approach used in many DEA efficiency studies on banks, output includes loans while inputs include salary expenses, branches and interest expenses[16]. Descriptive statistics for these variables are provided in Appendix 6. All variables are in peso values except for branches that refer to the number of branches at the end of the period. Monetary values over the period are adjusted (as recommended in Coelli et al., 2005) to 2000 levels considering possible price movements in all output and input commodities and services.

3.4 Hypotheses

Considering convention the foregoing and the limited data available for a detailed scrutiny, the study looks at three general hypotheses. Since this study will cover the period after the Asian financial crisis, it will be good to see if government policies to strengthen and stabilize the industry have paid-off. Thus, H_1: Efficiency of banks increased during 1999-2009. Whether bigger banks[17]

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13 The first window, for example, will include data for each of the bank groups for the years 1999-2004; the second window for the years 2000-2005; and, so on.

14 Program available for download from http://www.uq.edu.au/economics/cepa/deap.htm.

15 The interested reader is referred to www.bsp.gov.ph for the names of the banks classified according to bank groups for each of the years used in the study. It is understood that the list of banks per group can be different per year due to closures, mergers and acquisitions. New banks may have also opened during the period covered in the study.

16 Loans refer to total loan portfolio net of allowance for credit losses; salary expenses includes compensation and fringe benefits and other administrative expenses. Other income has not been included as output on the suggestion of the reviewers. As in many DEA studies involving banks, rounded-off values (here in billions of pesos) are used. It should be noted, however, that a reviewer has suggested using ratios (loans as a percent of total assets while salaries, interest expenses and other assets expressed as a percent of total expenses).

17 "Bigger" or "smaller" refers to bank groups' size based on capitalization requirements. Big banks, herein, include UBs and KBs while small banks include TBs, RBs and CBs.

are more efficient than smaller ones got mixed results based on existing studies. However, because the BSP continues to encourage banks to become bigger banks, the study looks at H_2: Bigger banks are more efficient than smaller banks (i.e., universal or commercial banks are more efficient than thrift, rural or cooperative banks). Technological advancements during the past 10 years that hasten delivery of banking services is evident and driven by computerization of banking processes (including loan evaluation and approvals). Literature also considers the proliferation of ATMs and the advent of online banking to be part of technological advances. We anticipate then that H_3: Banks must have undergone technological progress and therefore have experienced increases in total factor productivity.

4 Results and Discussions

Average CRS-TE hovers around 0.60 in most of the years considered in the study as shown in Table 1 below. It slightly increased in 2006-2008 but reverted back to original levels. Results show conspicuously very low scores for the UBs. Both RBs and CBs scores are around 0.50 to 0.60, although there is a noticeable increase during 2007 for RBs. Both KBs and TBs show scores above 0.80 but while KBs are able to maintain a score of 1.0 in most years, TEs decline in 2004 and 2005. These low scores anticipate the much higher values for VRS-TE, a likely indication that these banks are not operating at optimal levels.

Average VRS-TE generally shows the same trend in CRS-TE so that an almost constant level is experienced during the early years but would decline abruptly starting on 2007. Table 2 below shows that among bank groups, only KBs have very low (1999 & 2005) and very high episodes. KB's TE improvement since 2006 has been sustained in succeeding years. Only TBs appear to consistently get high scores. TEs of CBs and TBs continue to decline starting in 2006. Like TBs, RBs scored high but a very steep decline was experienced in 2009.

Table 1. Average CRS Technical Efficiency (CRS-TE) Per Bank Group Using DEA

Bank Group	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Universal	0.0390	0.0400	0.0397	0.0355	0.0344	0.0335	0.0324	0.0300	0.0260	0.0240	0.0200
Commercial	0.8920	1.0000	1.0000	1.0000	1.0000	0.8768	0.8046	0.9460	1.0000	1.0000	1.0000
Thrift	0.9280	0.9120	0.8643	0.9548	0.9498	0.9473	0.9664	1.0000	1.0000	1.0000	0.9690
Rural	0.6430	0.6055	0.5923	0.5905	0.6188	0.6132	0.6404	0.6620	1.0000	0.8820	0.4790
Cooperative	0.5040	0.5270	0.5650	0.5620	0.5960	0.5877	0.6236	0.6098	0.6280	0.6320	0.5560
AVERAGE	0.6012	0.6169	0.6123	0.6286	0.6398	0.6117	0.6135	0.6496	0.7308	0.7076	0.6048

Table 2. Average VRS Technical Efficiency (VRS-TE) Per Bank Group Using DEA

Bank Group	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Universal	0.9880	1.0000	1.0000	0.9875	0.9898	0.9945	0.9966	0.9698	0.9347	0.8535	0.7200
Commercial	0.8920	1.0000	1.0000	1.0000	1.0000	0.8795	0.8116	0.9705	1.0000	1.0000	1.0000
Thrift	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Rural	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9840	0.7240
Cooperative	1.0000	0.9930	1.0000	0.9563	1.0000	0.9877	1.0000	0.9908	0.9797	0.9415	0.8520
AVERAGE	0.9760	0.9986	1.0000	0.9888	0.9980	0.9723	0.9616	0.9862	0.9829	0.9558	0.8592

While technical efficiency estimates make it difficult to find support for H_1, that banks on the average are more technically efficient today, no significant difference[18] can be found when efficiencies in 1999 and 2009 are compared. H_2 may not be supported also by looking at the efficiency scores. KBs consistently keep high TE scores but the same cannot be said of UBs. DEA

[18] Uses Kolmogorov-Smirnov (K-S) Test (N1=N2=30; at 10% level) as discussed and illustrated in Banker, Janakiraman, & Natarajan (2004).

results also show TBs having very high scores. These differences, however, are also not statistically significant[19].

Table 3. Average Malmquist Index & Its Components Per Bank Group for 1999-2009

	EFFCH	TECHCH	PECH	SECH	TFPCH
UB	0.925	1.055	0.971	0.953	0.966
KB	1.018	1.009	1.019	0.999	1.027
TB	0.995	1.034	1.000	0.995	1.023
RB	0.989	1.083	0.972	1.010	1.106
CB	0.996	1.036	0.985	1.010	1.027

Average indices over the 11-year period in Table 3 above show that only RBs seem to exhibit improvement in total factor productivity (TFPCH). While KBs, TBs and CBs show slight increases, UBs show a decline in productivity. Appendix 1 shows that the average TFPCH for all bank groups per year did not changed much during 1999-2006. Its seemingly dormant behavior only changed due to the very big improvement in 2007[20] (index at 2.5287) and followed by the large drops in 2008 (at 0.8825) and 2009[21] (at 0.5430). It should be noted that all bank groups, except the KBs, follow the same decline in TFPCH starting in 2007 although on a much lower scale. Only KBs show improvement in TFPCH in 2009. It appears that productivity growth may have come from technological change (TECHCH) rather than technical efficiency change (EFFCH), as we find the average TECHCH for all banks over the years to be always greater than one. The average EFFCH, on the other hand, had its highs and lows over the years. It even declined in 2008-2009. Overall, KBs exhibited improvements while UBs showed a continually declining technical efficiency over the covered period. This is also evident in the behavior of average EFFCH indices in Table 3, which may be explained by the movements in pure technical efficiency change (PECH) and scale efficiency change (SECH).

Pure technical efficiency change (PECH) appears to have contributed to KBs' productivity growth based on Table 3. This raises questions regarding the managerial practices or the capability of bank management to manage inputs in generating desired loan outputs for other bank groups. Changes in PECH may also be attributed to difficulties faced by banks involved in mergers and acquisitions or competition in funds generation (e.g., from mutual funds). Appendix 2 shows KBs having a big improvement in 2000 and an even bigger improvement in 2006, even though it dipped in 2004. Further, while KBs' and TBs' PECH did not change in 2008-2009, all the others' PECH declined. The huge deterioration in PECH for RBs in 2009 also caused the drop in its TFPCH. It should be noted that TBs have kept its PECH unchanged over the years and that UBs' PECH show a clear decline starting in 2005. The low mark of 0.846 in 2009 is a clear culprit for UB's low TFPCH in 2009.

Scale efficiency change (SECH) may have slightly contributed to RBs' and CBs' productivity growth by looking at Table 3. This is an indication that both RBs and CBs have benefitted from an increase in scale size. Appendix 3 shows that RBs have been moving toward an efficient scale since 2000. A very big jump in SECH was experienced in 2007 but this was followed by steep declines in 2008-2009. With an index below one during these last two periods, it may be an indication that the group has gone below or over its optimal scale already. This clearly caused the decline in RBs'

[19] None of the K-S Tests (N1=N2=6 at 10% level; comparing pairs of banks groups for different time periods) show any significant differences in bank groups' efficiencies.

[20] RBs gained double-digit growth in assets, loan portfolio, deposit liabilities and capitalization; nonperforming loans (NPLs), however, rose; and, 15 RBs closed due to insolvency (Adapted from BSP's A Status Report on the Philippine Financial System, 1st & 2nd Semester 2007).

[21] Business conditions were difficult for RBs in 2009: credit only grew by 1.7% while simultaneously experiencing a faster increase in NPLs to 10.1%. Twenty-seven RBs were closed during the year. Since RBs continue to play an important role in agricultural development, the huge production losses brought about by natural calamities during the year also stunted the RB's growth in lending to the agriculture, fishery, hunting and forestry sector. (Source: A Status Report on the Philippine Financial System, 1st & 2nd Semester 2009, BSP).

TFPCH in 2009. No sudden changes could be observed for CBs. While it experienced SECH improvements in 2000-2002, SECH declined in 2009-2009. TBs did not show much erratic movement but also declined in 2008-2009. KBs have remained unchanged. Worth noting is the movement of UBs' SECH. While it was below one, this improved in 2008-2009 when others were going down. It could be surmised that UBs may have taken longer time to adjust from the financial crisis in 1997 and the reforms that were implemented thereafter. This somehow contributed to UBs' productivity growth in the last two years covered in the study.

Based on Table 3, technological change (TECHCH) appears to be a common source of productivity for most banks. With indices greater than one, these banks have undergone technological progress and are able to increase their total loan portfolios given compensation and administrative expenses, the number of branches used that solicit and accommodate loan processing and transactions, and the cost of borrowed funds. More specifically, these could mean that banks have been more innovative in their loan products; gained more access to loan clients (with online applications); shortened approval times (given the online approval of applications); and, also more innovative in their deposit products that could lower the cost of borrowed funds. On a yearly basis, Appendix 4 shows that UBs have experienced technological improvement for most of the years (2002-2007). It is also clear that TECHCH was a big source for productivity growth for RBs in 2007. In 2009, only KBs and CBs improved while all others maintained the same level.

H_3 may not be fully supported based on the values of the components of the Malmquist index. While technological progress contributed to all of bank groups' productivity growth, the very low indices for scale efficiency change and pure technical efficiency change in 2008-2009 dampened growth in total factor productivity. As in the first two hypotheses, no significant differences[22] can be found when comparing the TECHCH, PECH, SECH and TFPCH in 1999 and 2009. This may be likely because of the limited number of input and output variables used in the study.

5 Conclusions and Future Directions

The study has shown how bank groups' relative efficiencies could be determined using DEA. The Malmquist index and its components have also been useful in identifying the likely sources for productivity progress or regress. Considering the efficiency scores, the study finds little or no support to accept that banks are more efficient today, that bigger banks are more efficient than smaller banks and that banks must have undergone technological progress so that total factor productivity would have increased. The study's main contribution so far has been to show a declining trend in technical efficiencies and identify the components that may have contributed to productivity growth. These findings, however, cannot be rendered conclusive considering the failure to find statistical differences in the efficiency scores and efficiency changes throughout the period covered by the study. While the study cannot find statistical support for the three hypotheses, it suggests a further investigation and an improvement of the methodology to better explain the movements in efficiency indices[23]. It can be surmised that using bank groups as DMUs, given the choice of variables used in the study, may not be sufficient to show variations in efficiency scores and total factor productivity.

A logical direction in the future is to come up with a study using individual banks as samples for each of the groupings for further hypotheses testing. The use of environmental variables in a two-stage DEA could also explain why the changes in efficiency measures may have behaved as such. This points to another study that thoroughly reviews changes in policies that affected the banking industry to validate the behavior of bank efficiencies in this study. This, incidentally, has not been the focus of the current study. Parametric frontier estimation may also be considered given the attractiveness of the SFA model, as it specifies both errors due to random errors and due to inefficiency. However, along with the challenge in choosing the appropriate model in SFA, one has to deal as well with the few number of DMUs.

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[22] Use of K-S Tests (N1=N2=30 at 10% level).

[23] It should be noted that a reviewer has asked about the significance of the study given the findings that the hypotheses are not supported. This author has been reminded as well about how offering underlying or possible causes could improve this paper.

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APPENDIX 1

Average Total Factor Productivity Change (TFPCH) Per Bank Group

Bank Group	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Universal	1.0280	0.9830	0.9677	1.0098	1.0056	1.0014	0.9563	0.9500	0.9000	0.8600
Commercial	1.1210	0.9960	0.9963	0.9983	0.8640	0.9150	1.1965	1.0777	1.0095	1.0970
Thrift	1.0110	0.9865	1.1320	1.0018	1.0024	1.0340	1.0648	1.0257	1.0050	0.9690
Rural	0.9570	0.9970	1.0070	1.0540	0.9940	1.0570	1.0440	2.5287	0.8825	0.5430
Cooperative	1.0440	1.0720	0.9950	1.0610	1.0028	1.0668	0.9798	1.0310	1.0465	0.9690
AVERAGE	1.0322	1.0069	1.0196	1.0250	0.9738	1.0148	1.0483	1.3226	0.9687	0.8876

APPENDIX 2
Average Pure Efficiency Change (PECH) Per Bank Group

Bank Group	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Universal	1.0130	1.0000	0.9890	1.0035	1.0062	1.0030	0.9738	0.9643	0.9145	0.8460
Commercial	1.1210	1.0000	1.0000	1.0000	0.8820	0.9356	1.2120	1.0417	1.0000	1.0000
Thrift	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Rural	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9840	0.7360
Cooperative	1.0000	1.0075	0.9567	1.0458	0.9888	1.0148	0.9908	0.9920	0.9650	0.8880
AVERAGE	1.0268	1.0015	0.9891	1.0099	0.9754	0.9907	1.0353	0.9996	0.9727	0.8940

APPENDIX 3

Average Scale Efficiency Change (SECH) Per Bank Group

Bank Group	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Universal	1.0150	0.9750	0.8897	0.9380	0.9444	0.9436	0.9173	0.9120	0.9820	1.0160
Commercial	1.0010	1.0000	1.0000	1.0000	0.9970	0.9944	0.9860	1.0097	1.0000	1.0000
Thrift	0.9550	0.9140	1.0907	0.9828	0.9868	1.0160	1.0330	1.0000	1.0000	0.9690
Rural	0.9250	0.9600	0.9820	1.0343	0.9792	1.0412	1.0330	1.5097	0.8970	0.7380
Cooperative	1.0440	1.0645	1.0400	1.0145	0.9934	1.0296	0.9658	1.0167	1.0240	0.9070
AVERAGE	0.9880	0.9827	1.0005	0.9939	0.9802	1.0050	0.9870	1.0896	0.9806	0.9260

APPENDIX 4

Average Technological Change (TECHCH) Per Bank Group

Bank Group	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Universal	1.0000	1.0085	1.1207	1.0895	1.0728	1.0732	1.0870	1.0970	1.0020	1.0000
Commercial	1.0000	0.9960	0.9963	0.9983	0.9836	0.9842	1.0018	1.0257	1.0095	1.0970
Thrift	1.0590	1.0795	1.0393	1.0200	1.0164	1.0184	1.0318	1.0257	1.0500	1.0000
Rural	1.0340	1.0385	1.0257	1.0193	1.0154	1.0156	1.0110	1.6750	1.0005	1.0000
Cooperative	1.0000	1.0000	1.0000	1.0000	1.0228	1.0230	1.0265	1.0233	1.0635	1.2040
AVERAGE	1.0186	1.0245	1.0364	1.0254	1.0222	1.0229	1.0316	1.1693	1.0251	1.0602

Appendix 5

Bank Groups, Description & Classification Based on Capital Requirements

TYPE OF BANK	SHORT DESCRIPTION[24]	CAPITAL REQUIREMENTS (In Millions Pesos)
Universal Banks (UBs) Commercial Banks (KBs)	UBs and KBs represent the largest single group, resource-wise, of financial institutions in the country. They offer the widest variety of banking services among financial institutions. In addition to the function of an ordinary KB, UBs are also authorized to engage in underwriting and other functions of investment houses, and to invest in equities of non-allied undertakings.	4,950.0 2,400.0
Thrift Banks (TBs) With head office in Metro Manila With head office in cities of Cebu & Davao Other Areas	The thrift banking system is composed of savings and mortgage banks, private development banks, stock savings and loan associations and microfinance thrift banks. TBs are engaged in accumulating savings of depositors and investing them. They also provide short-term working capital and medium- and long-term financing to businesses engaged in agriculture, services, industry and housing, and diversified financial and allied services, and to their chosen markets and constituencies, especially small- and medium- enterprises and individuals.	 1,000.0 500.0 250.0
Rural Banks (RBs) In Metro Manila Cities of Cebu & Davao In all other cities 1st to 4th class municipalities 5th & 6th class municipalities Cooperative Banks (CBs)	RBs and CBs are the more popular type of banks in the rural communities. Their role is to promote and expand the rural economy in an orderly and effective manner by providing the people in the rural communities with basic financial services. Rural and cooperative banks help farmers through the stages of production, from buying seedlings to marketing of their produce. Rural banks and cooperative banks are differentiated from each other by ownership. While rural banks are privately owned and managed, cooperative banks are organized/owned by cooperatives or federation of cooperatives.	 100.0 50.0 25.0 10.0 5.0 10.0

Note. Adapted from www.bsp.gov.ph

[24] A complete listing of the powers and scope of authority of banks are indicated in Bangko Sentral ng Pilipinas' Circular No. 271 Series of 2001.

APPENDIX 6
Descriptive Statistics for Variables Used in the Study (1999-2009)

Loans (in billion pesos)

Bank Type	Max	Median	Min	Mean	Std. Dev
UB	2,226.468	1,333.397	1,144.535	1,483.547	366.756
KB	410.970	352.487	283.638	349.909	39.829
TB	309.645	162.380	120.168	194.586	71.613
RB	94.303	56.401	36.327	61.638	22.901
CB	10.386	4.530	3.400	5.459	2.376

Salaries & Wages (in billion pesos)

Bank Type	Max	Median	Min	Mean	Std. Dev
UB	112.756	58.171	46.120	67.326	22.728
KB	20.350	12.511	10.842	13.980	3.348
TB	18.706	9.382	7.921	11.611	4.185
RB	10.493	5.008	3.247	5.631	2.434
CB	0.925	0.386	0.267	0.464	0.218

No. of Branches

Bank Type	Max	Median	Min	Mean	Std. Dev
UB	4,009	3,694	3,504	3,725	148
KB	746	600	474	604	102
TB	1,478	1,322	1,277	1,330	61
RB	2,605	1,897	1,778	1,950	235
CB	162	111	103	117	17

Interest Expenses (in billion pesos)

Bank Type	Max	Median	Min	Mean	Std. Dev
UB	106.716	89.314	69.450	88.006	11.857
KB	31.888	22.404	17.473	23.473	5.157
TB	17.656	13.816	9.422	13.935	2.859
RB	6.720	4.354	3.811	4.915	1.083
CB	0.830	0.406	0.324	0.475	0.164

Note. Adapted from www.bsp.gov.ph