Productivity and Efficiency of the Malaysian and Philippine Banks: Malmquist Productivity Index and Slack-Based Measure

Review of Integrative Business & Economics Research

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ABSTRACT

The Global Financial Crisis led bank policymakers to reevaluate their operations to circumvent potential bailout costs and protect their long-term sustainability. This study examines the efficiency and total factor productivity of selected commercial banks in the Philippines and Malaysia for the period 2011-2018 using Malmquist Productivity Index and Data Envelopment Analysis (Malmquist-DEA) and applied slack-based measure (SBM) to determine the inputs and/or outputs needed by each Decision-Making Unit (DMU) for their efficiency. The results revealed that Philippine banks performed better than Malaysian banks. Technical efficiency from both pure technical and scale efficiencies led to the increase in the average Malmquist productivity index. Technological deficiencies were evident among DMUs, especially in Malaysia. The declining total factor productivity were a product of the downward shift in the frontier. Only four banks maintained the most productive scale size (MPSS) of operations, while the majority experienced decline in return to scale. Under the CRS and VRS assumptions, inefficient banks can shift towards the frontier through the efficient utilization of resource inputs. This provides policy implications for all types of banks worldwide to closely monitor their efficiency and productivity by leveraging their positions for creating and/or improving their business activities.

Keywords: DEA-Malmquist Productivity Index, Decision Making Units, Technical Efficiency.

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1. INTRODUCTION

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Internationalization and digitalization led to the increase in real-time cross-border transactions, which prompted banks to be efficient. Its overall efficiency is crucial in determining the best approach for providing, designing, or products and services, and for efficiently allocating available resources. Larger banks and those operating in cities perform better compared to small banks and those operating in rural areas (Bansal *et al*., 2022, Dar *et al*., 2021). Achieving optimal productivity is one of the primary objectives of the banks, as it can have positive and significant effects on their operations, the business community, and the economy.

While most studies utilized basic Data Envelopment Analysis (DEA), some applied additional statistical models, such as regression-based feedback (Ouenniche & Carrales, 2018), second stage DEA (Azad *et al*., 2020; Gulati & Kumar, 2017; Patra *et al*., 2023), meta-frontier approach (Saffiullah & Shamsuddin, 2022, Ul Hassan Shah *et al*., 2022), Stochastic Frontier approach (Berro, 2023; Ngo & Tripe, 2017, Osuagwu *et al*., 2018), and others. They believe that utilizing a combination of these methodologies will be better. It also allows evaluating changes in the productivity over time and across companies (Bayiley, 2022).

Despite several studies that were made on total factor productivity (Cheriye, 2020; Shair, 2020; Wan & Zhou, 2021; Bhuyan, *et al*., 2021; Bayiley, 2022), there still exists a gap in the extant literature using Malmquist-DEA in the Philippines (Sufian, 2012) and in Malaysia (Yildirim, 2015). This study fills this gap by applying these two models in examining the overall productivity and efficiency of commercial banks in the Philippines and Malaysia. It also examines excess inputs and output shortfalls on the performance of the banks. The authors believe that understanding the total factor productivity, its sources of efficiency, and the fusion and contribution of sub-optimal input variables to achieve desirable outputs, will facilitate in assessing bank efficiency and in producing key strategic plans to improve the overall performance related to their intermediation activities of these banks but also other banks in ASEAN region and other countries.

2. REVIEW OF RELATED LITERATURE

2.1 Malmquist-DEA as an Efficiency Tool

Malmquist-DEA models measure productivity changes over time (Bayiley, 2022; Li *et al*., 2021) and facilitate in identifying whether bank performance remains the same (constant), is improving or weakening. It allowed DMUs to decompose the changes in productivity into technological and technical efficiency (Ashiagbor *et al*., 2023; Li *et al*., 2021; Kamarudin *et al*., 2017; Kaur & Aggarwal, 2017; Prakash *et al*., 2022). It also provided better results compared to other measures of productivity changes (Soltane Bassem, 2014). Other studies computed changes in DMU's productivity by combining Malmquist Productivity Index (MPI**)** with Tornqvist index or Fisher index (Idowu, 2019; Kamarudin *et al*, 2017).

Bansal *et al*. (2022) applied Dynamic Malmquist-Luenberger Productivity Index (DMLPI) and Dynamic Sequential MLPI (DSMLPI) to examine three levels of productivity using deposit liabilities, lending activity, and revenue generation among 42 Indian banks. DMLPI model showed that thirty-five banks exhibited declining productivity during 2011-2017 period. DSMLPI model proved to be better in measuring productivity and efficiency where Indian banks exhibited technical progression resulting from increased productivity, as contrasted to the results generated by the dynamic MLPI. Results also revealed that private banks performed better than public banks and

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technological advancement contributed to their performance, which is consistent with the findings of Dar *et al*. (2021).

2.2. Slack-Based Model

The super-efficiency slack-based model (SSBM) provides a better perspective in evaluating the efficiency of DMUs in actual scenarios by ranking the banks and analyzing efficiency differences based on their size or other measures (Tamatam *et al*., 2019). They used six slack-based and three radial-based models. They noted that slack-based model utilizes minimal input/(s) to determine the maximum outputs in measuring a DMU's efficiency. Results revealed that most banks were efficient using sensitivity analysis. With the exclusion of efficient banks from the analysis, there was a remarkable change in technical efficiency. In contrast, Duho (2020) mentioned that this non-radial technique provides misleading interpretation on the efficiency results generated by the DEA model. Since banks have different priorities and goals, other banks will utilize excess inputs to produce the same amount of output or generate lesser outputs with the same number of inputs or a combination of inputs compared to other banks on the frontier.

Abdulahi *et al*. (2023) utilized intermediation and production approaches and revealed that productivity increased during the first year, followed by a decline during the succeeding years, and an increase thereafter. Despite the improvement in the Ethiopian banks' efficiency, they exhibited average productivity below 1, which means that these banks are performing below their capacity. In another study, Azad *et al*. (2020) applied a two-stage slack-based model for its core and additional operations. Results revealed that Bangladesh banks are inefficient, with average efficiency scores of 95.05 percent, and two banks were significantly inefficient. Public banks encountered problems with their additional operations while private banks suffered from their core activities. Fu & Heffernan (2007, as cited in Sufian, 2014) showed that Joint Stock Commercial Banks enjoyed greater economies of scale and achieved constant return to scale (CRS) in all phases of financial sector reforms in China compared to State-Owned Commercial Banks, as constant return to scale (CRS) and efficiency were only evident during the 2nd phase.

Prakash *et al*. (2022) reported that banks in India reduced their costs by 17 percent without changing existing inputs. Allocative inefficiency resulted to cost inefficiency and growth in total factor productivity came from technological changes and the innovations introduced by banks. Like the findings of Bansal *et al*. (2022), private banks performed better compared to public banks due to their adherence in monitoring risks and the introduction of mechanisms to control risks. Bangarwa & Roy (2023) applied dynamic slack-based model (DSBM) and undesirable slack-based model (USBM) and found that DSBM outperformed USBM. The use of net worth, deposits, operating expenses, and fixed assets as input variables contributed to the efficiency of banks.

3. FRAMEWORK OF THE STUDY

Aikaeli (2008, as cited in Pathak, n.d.) defined efficiency as the "level of performance that describes a process that uses the lowest number of inputs to create the greatest number of outputs." In this study, efficiency measures how well a bank utilizes its resources (e.g.: assets) to achieve a desired output. Efficiency is associated with productivity, which refers to the bank's ability to allocate its input to yield maximum output (Tan, 2016).

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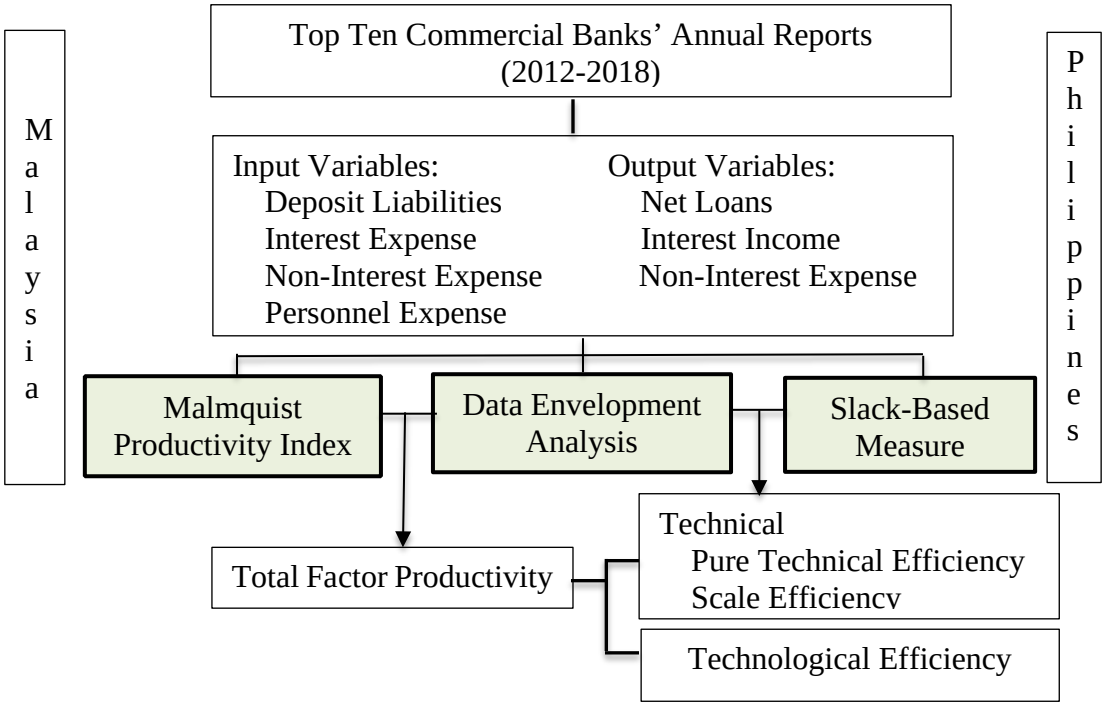

Figure 1. Conceptual Framework

As shown in Figure 1, the authors used financial statements to collect data for the input and output variables used in the DEA-Malmquist model. Li *et al.* (2021) computed the changes in the total factor productivity (TFPRCH) to measure the efficient usage of resources and allocation of funds from investors to borrowers. This model is based on the study of Pathak (n.d.) and is a modified version of the study of Zhu & Zhang (2018).

Both input and output variables used in the study were based on the intermediation approach applied by Pathak (n.d.) and Gunawan and Utiyati (2013, as cited in Yonnedi & Panjaitan, 2019). The input variables include interest expense, non-interest expense, deposit liabilities, and personnel expense. For the deposits, the bank incurs a cost in the form of interest expense. Seta (2022) mentioned that while deposits are the cheapest and main sources of funds, banks must exercise due diligence to ensure its principal/depositor their safety and soundness. Like deposits, loans are also the largest earning assets, and banks earn interest income. Another output variable used in the study is non-interest income (see Figure 1).

Using Malmquist-DEA, the study evaluates the changes in total factor productivity (TFPRCH) and its subcomponents, namely, technological (TCHNCH) and technical (TEEFCH) efficiencies. Technical Efficiency (TEEFCH) refers to the performance of a bank in minimizing inputs while maximizing output based on the constant returns to scale (Zhu & Zhang, 2018). Additionally, TEEFCH consists of scale efficiency (SCEFCH) and pure technical efficiency (PURTCH) based on the variance returns to scale (Soltane Bassem, 2014). They have a value between 0 and 1, which measures whether a bank is performing efficiently or not. A ratio of 1 signifies that the bank is performing efficiently.

Yu Sheng and Ibrahim (2019, as cited in de Jager *et al*, 2022) noted that technological innovation facilitates prompt service delivery (e.g.: online banking) and provides competitive advantage to the DMUs. It also increases profitability and technological

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efficiency. Esmaeili (2022) emphasized the need to track changes in the productivity of a DMU and to compare results with other DMUs and with the previous years.

Figure 1 shows that this study also employed slack-based measure to determine productivity and efficiency (Abdulahi *et al*., 2023; Bangarwa & Roy, 2023; Le *et al*., 2019; Prakash *et al*., 2022; Tamatam *et al*., 2019). The authors computed slacks, based on the assumption that inefficient banks can reach the efficient frontier by reducing excess input variables with the slack quantity without experiencing any issues thereto. Banks should eliminate excess input wastage to become efficient.

4. METHODOLOGY

4.1 Research Design

Causal/explanatory research design examines the nature and sources of the efficiency of banks in Malaysia and the Philippines using Malmquist Productivity Index and Data Envelopment Analysis. The descriptive research design analyzes the performance of the banks and compare them across time, with other banks or groups of banks.

4.2 Method of Data Collection

The study collected secondary data from the financial data found in the annual reports of the banks in the Philippines and Malaysia, and from the reviewed materials and studies such as online journals, e-books, and thesis/dissertations.

Table 1. Top Ten Commercial Banks in the Philippines & Malaysia*

Banks in the Philippines	Abbreviation Used	Banks in Malaysia	Abbreviation Used
Asia United Bank	AUB	AFFIN Bank	ABM
Banco de Oro Unibank, Inc.	BDO	Alliance Bank Malaysia	ABM
Bank of the Philippine Islands	BPI	AMMB Holdings	AMBB
China Banking Corp	CBC	CIMB Group Holdings	CIMB
Metropolitan Bank & Trust Company	MBT	Hong Leong financial Group	HLFG
Philippine Bank of Communications	PBC	Malayan Banking Berhad	MBB
Philippine National Bank	PNB	OCBC Bank Malaysia	OCBC
Rizal Commercial Banking Corp.	RCBC	Public Bank	PB
Security Bank Corp.	SBC	RHB Islamic Bank BHD	RHB
Union Bank of the Philippines	UBP	United Overseas Bank	UOB

Note: Based on the Total Assets as of 2018

The authors utilized purposive sampling in their study. Among the ASEAN-member economies, banks in the ASEAN5 have developed financial systems, despite the significant disparities in the residents' religious systems. In 2022, 87.02% of Indonesia's population are Muslims (DataIndonesia.ID., 2023), 67.5% of Malaysia's population in 2020 are also Muslims (Statistics Malaysia, 2022), while 92 % of Thailand's residents are Buddhists (Statista Research Department, 2023). Among the developing countries in the ASEAN5 economies, both Philippines and Malaysia have the same level of economic

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development and their banking system are developed compared to Thailand and Indonesia. Likewise, there were limited studies that were conducted on bank efficiency and productivity in these countries. Singapore was excluded in the selection process, as it is classified as a developed economy. The selection of the Top 10 commercial banks operating in the Philippines and in Malaysia was based on their total assets as of 2018 (see Table 1). The authors also excluded foreign-owned banks whose headquarters are located abroad. The banks selected must have operated prior to 2011 and must have consistently operated from 2011 to 2018.

4.3 Method of Data Analysis

This study applied DEA and Malmquist Productivity index to measure and compared the productivity and efficiency of banks operating in Malaysia and the Philippines. Under the intermediation approach derived from the study of Zhu & Zhang (2018) and Pathak (n.d.), the input variables (interest expense, non-interest expense, deposit liabilities, and personnel expense) and output variables (interest income, non-interest income, and net loans) were used to determine the TFPCH of the banks and its subcategories, namely, TECHCH, EFFCH, PECH, and SECH using Malmquist-DEA (see Figure 1).

The Production Possibility Frontier is the optimum mix of goods generated from use of resources and technology. Salas-Velasco (2018) stated that "a production frontier utilizes the maximum output of a given set of inputs and production" technology. This concept, as applied in the study, uses a model of variables from secondary sources to compute for the efficiency and TFPRCH of each commercial bank. According to Pathak (2010): "The MPI is based on distance functions, output distance functions for an output- oriented index and input distance functions for an input-oriented index. The index is applied to the measurement of total factor productivity change over time and can be decomposed into an efficiency change index and a technological change index". The number falls between 1 and 0. A score of 1 corresponds to the commercial bank performing efficiently while a value of less than 1 is deemed to be inefficient. The following assumptions should be followed: the values of the formula should always be positive.

Technical Efficiency is based on the DMU's efficient usage of input variables where the optimal result should be an efficiency score of 1, and anything less than 1 signifies inefficiency in the DMU's production (Banker *et al*., 1984, as cited by Vidyarthi, 2019). Iqbal & Awan (2015) mentioned that pure technical efficiency shows how much a DMU can decrease its outputs while maintaining within the VRS frontier while scale efficiency refers to the prediction of the VRS frontier that limits the inputs of the DMU while sustaining within the CRS frontier. The variable rate of return's primary focus is on the production aspect of efficiency while the constant rate of return focuses on the consistency of the inputs and outputs.

The authors also utilized a slack-based model proposed by Tone (2001, as cited in Antunes *et al*., 2024; Ohsato & Takahashi,2015) to derive the slacks from inefficient banks using by determining the excess input and slack output variables. Input variables utilized in the study include interest expense, non-interest expense, deposit liabilities, and personnel expense, while output variables comprise interest income, non-interest income, and net loans. Likewise, these variables were used to compute for the five indices using Malmquist-DEA, namely, total factor productivity (TFPRCH), technological efficiency

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(TCHNCH), technical efficiency (TEEFCH), pure technical efficiency (PURTCH), and scale efficiency (SCEFCH).

5. RESULTS AND DISCUSSIONS

Table 2. Total Factor Productivity Means of Philippines & Malaysian Banks (2011-2018)

COUNTRY	2011	2012	2013	2014	2015	2016	2017	2018
Malaysia	0.993	0.975	0.988	0.988	0.977	0.940	0.975	0.991
Philippines	0.993	0.988	0.992	1.000	1.000	0.996	0.997	0.996

Source: Authors' computation from DEAP v. 2.1 software

Table 2 shows the Malmquist index averages (TFPRCH) of the Philippine and Malaysian commercial banks from 2011 to 2018. It measures the changes (progression or regression) in the total factor productivity of these banks. It reveals that Philippine banks performed better compared to Malaysian banks, as measured by their mean Malmquist indices (TFPRCH). Despite the decline in the banks' productivity in both countries, banks in the Philippine showed improvement in 2014 while banks in Malaysia exhibited an increase in the average TFPRCH in 2013 but declined again in 2015 until 2016. Malaysian banks consistently exhibited inefficiency scores in all years and only gained the highest average TFPRCH score of 0.993 in 2011. Their productivity scores declined until 2016 but showed improvements in in 2017 and 2018. Philippine banks showed increasing total factor productivity until 2015 and recorded the lowest score in 2012 (0.988).

The summary of the annual mean scores of individual DMUs operating in the Philippines and Malaysia for the total factor productivity (TFPRCH) is decomposed into technical efficiency change (TEEFCH) and technological change (TCHNCH). Technical efficiency (TEEFCH) comprises pure-technical change (PURTCH), and scale efficiency change (SCEFCH).

Table 3 shows that eleven banks were efficient during the period, where they consistently garnered a TFP score ≥ 1. Seven of these banks are operating in the Philippines while four banks operate in Malaysia. The mean Malmquist index (TFPRCH) for the entire sample is 1.001, which means that there is a 0.1% increase in their overall efficiency. Philippine banks recorded an average Malmquist Index (TFPRCH) level of 1.003, indicating an overall increase in productivity by 0.3%, as contrasted to Malaysian banks' average TFPRCH of 0.999. Malaysian banks' low average Malmquist index proved that there was decline in their overall productivity by .001 percent, despite the TCHNCH mean score of 1.003. Likewise, six banks exhibited improvement in all five efficiency indices, with four (4) banks operating in the Philippines and two (2) in Malaysia.

Nine banks were inefficient, as shown in their TFPRCH scores of less than 1. Table 3 shows that CIMB, AMMB, and RCBC were only inefficient in 2016. Over the years, Malaysia was known as the second biggest producers of oil in Southeast Asia and the drastic oil price decrease in 2016 had affected their economy (Andolu Agency, 2016). While PNB TFPRCH scores were below 1 from 2011 to 2013, they became efficient during the succeeding years. For the rest of the inefficient banks, their Malmquist index changed each year, and various banks were inefficient during the period.

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Table 3. Malmquist Productivity Index and its Decomposition's Summary of Annual Means of DMUs for the Period 2011 to 2018

	BANK	COUNTRY CODE	TFPRCH	TEEFCH	TCHNCH	PURTCH	SCEFCH
1	PNB	PH	1.054	1.010	1.043	1.007	1.003
2	AUB	PH	1.049	1.000	1.049	1.000	1.000
3	BDO	PH	1.027	1.100	1.027	1.000	1.000
4	UOB	MAL	1.019	1.000	1.019	1.000	1.000
5	AB	MAL	1.016	1.017	0.999	1.001	1.016
6	BPI	PH	1.016	1.007	1.009	1.000	1.007
7	CBC	PH	1.015	0.995	1.021	0.997	0.997
8	MBT	PH	1.014	1.017	0.997	1.000	1.017
9	CIMB	MAL	1.006	1.011	0.995	1.000	1.011
10	PBC	MAL	1.005	1.000	1.005	1.000	1.000
11	ABM	MAL	1.003	1.006	0.997	1.002	1.004
12	RHB	MAL	0.995	0.999	0.996	0.995	1.005
13	MBB	MAL	0.993	1.000	0.993	1.000	1.000
14	AMMB	MAL	0.993	1.000	0.993	1.000	1.000
15	RCBC	PH	0.993	1.000	0.993	1.000	1.000
16	OCBC	MAL	0.99	1.000	0.990	1.000	1.000
17	HLFG	MAL	0.97	1.000	0.970	1.000	1.000
18	SBC	PH	0.968	1.000	0.968	1.000	1.000
19	UBP	PH	0.956	1.000	0.956	1.000	1.000
20	PBC	PH	0.937	1.000	0.937	1.000	1.000
		mean	1.001	1.003	0.997	1.000	1.003
		PH mean	1.003	1.003	1.000	1.000	1.003
		MAL mean	0.999	1.003	0.996	1.000	1.004

Notes: Total factor productivity change (TFPRCH), technical efficiency change (TEEFCH), technological change (TCHNCH), pure efficiency change (PURTCH), scale Efficiency change (SCEFCH)
Source: Authors' computation from DEAP v. 2.1 software

The average TEEFCH and TCHNCH are 1.003 (0.3% increase) and 0.997 (0.3% decrease), respectively. There were eighteen banks that were technically efficient (18 out of twenty banks) and only CBC (0.995) and RHB (0.999) were technically inefficient. In terms of technological efficiency, seven banks (BDO, BPI, PNB, CBC, AUB, PB and UOB) showed improved performance in their TCHNCH scores. AUB showed the highest growth rate in TCHNCH (4.9% increase), while PBC got the lowest TCHNCH 0.937, representing 6.3% decrease. This means that the DMUs overall productivity comes from technical efficiency rather than technological efficiency.

When decomposing technical efficiency, it showed that the average pure technical (PURTCH) and scale (SCEFCH) efficiencies are 1.000 and 1.003, respectively Only CBC and RHB experienced a decrease in their managerial efficiency, as showed in their pure technical efficiency index (PURTCH). PNB reflected significant improvements in PURTCH, followed by ABM and AB banks in Malaysia. For the other banks, their managerial efficiency remained unchanged (PURTCH = 1.0). For the individual DMUs administrative efficiency (SCEFCH), only CBC was inefficient, as shown in the decline in SCEFCH by 3%.

Both pure technical (1.000) efficiency and scale efficiency (1.004) supported the progression in technical efficiency, respectively. The overall inefficiency of most

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Malaysia banks emanated from technological inefficiencies (0.996), which is consistent with the results of the study of Trinh Doan Tuan (2020) where Malaysian banks recorded the lowest average efficiency scores during the period 2013-2017 compared to other ASEAN4 banks. This only means that banks should prioritize their technological efficiency to improve their productivity and operational efficiency.

Table 4. Year-on-Year Malmquist Productivity Index Results during 2011-2018

YEAR	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	MEAN
TFPRCH	1.019	1.048	1.009	0.976	1.060	0.937	0.961	1.001
TEEFCH	0.995	1.015	0.991	1.014	0.959	1.044	1.006	1.003
TCHNCH	1.024	1.033	1.019	0.963	1.105	0.897	0.955	0.997
PURTCH	0.988	1.009	1.004	0.994	0.978	1.020	1.008	1.000
SCEFCH	1.008	1.006	0.986	1.019	0.981	1.024	0.999	1.003

Notes: Total factor productivity change (TFPRCH), technical efficiency change (TEEFCH), technological change (TCHNCH), pure efficiency change (PURTCH), scale Efficiency change (SCEFCH)
Source: Authors' computation from DEAP v. 2.1 software

Table 4 reveals the summary of the overall productivity changes, its constituents, and their sub-components from 2012 t0 2018. The results revealed that productivity and efficiency measures showed erratic changes over the seven-year period (2012-2018). The highest score of TFPRCH occurred in 2013 with 1.048 but showed a drastic decline in its average scores in 2014 by 3.83%. This is lower, compared to the decline in 2017 where the average Malmquist productivity index was only 0.937 compared to 1.060 (2016). Hence, the TEEFCH and SCEFCH scores increased in 2014. In 2015 and 2017, TCHNCH and PURTCH scores declined except for the technical (TEEFCH) and scale efficiency (SCEFCH) which showed improvement during these periods.

There was a minimal 0.1% increase in the total factor productivity index which is lower than the technical efficiency changes of 0.3%. The increase in technical efficiency's mean score came from the 0.3% increases in both PURTCH and SCEFCH. This is consistent with the findings of Ul Hassan Shah *et al*. (2022) where they revealed that technical efficiency positively affects total factor productivity among South Asian banks. However, our findings on the erratic movement of overall productivity are in contrast with their findings where TFPRCH declined over the period. On the other hand, the findings of Abdulahi *et al*. (2023) revealed that overall productivity was induced by improvements in technological innovations introduced by banks in Ethiopia. This is in contrast with our findings where the banks exhibited technological inefficiencies (0.997) from 2017 to 2018.

Philippine banks exhibited increase in total factor productivity, technical efficiency, technological efficiency, pure technical efficiency, and scale efficiency increases by 1.0%, 0.4%, 0.6%, 0.1% and 0.3%, correspondingly. These banks performed efficiently during the seven-year period. Malaysian banks showed a 1.0% decline in their overall productivity (TFPRCH = 0.990) due to a 2.8% decline in technological efficiency despite a 1.8% increase in technical efficiency. Table 4 revealed that technical efficiency (TEEFCH) emanates from increases in both pure technical efficiency (PURTCH) and scale efficiencies (SCEFCH) by 1.8% and 0.1%, respectively. Except for the level of

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technological efficiency (TCHNCH), all other indices, namely technical, pure technical, scale efficiencies increased by 2.6%, 0.01% and 0.3%, respectively.

Table 5. Summary of Efficiency Scores of DMUs using Three Models

Bank Name*	TCHNCH	CRSTE**	VRSTE***	Scale (CRSTE/ VRSTE)	RTS
AUB	1.049	1.000	1.000	1.000	crs
BDO	1.027	1.000	1.000	1.000	crs
UOB	1.019	1.000	1.000	1.000	crs
PB	1.005	1.000	1.000	1.000	crs
RCBC	0.993	1.000	1.000	1.000	crs
MBB	0.993	1.000	1.000	1.000	crs
AMMB	0.993	1.000	1.000	1.000	crs
OCBC	0.99	1.000	1.000	1.000	crs
HLFG	0.97	1.000	1.000	1.000	crs
SBC	0.968	1.000	1.000	1.000	crs
UBP	0.956	1.000	1.000	1.000	crs
PBC	0.937	1.000	1.000	1.000	crs
BPI	1.009	0.955	1.000	0.955	drs
RHB	0.996	0.968	1.000	0.923	drs
CIMB	0.995	0.923	1.000	0.887	drs
MBT	0.997	0.887	1.000	0.968	drs
PNB	1.043	0.931	0.953	0.997	drs
CBC	1.021	0.955	0.976	0.978	drs
AB	0.999	0.841	0.940	0.894	drs
ABM	0.997	0.956	0.986	0.970	drs
No. of Efficiency	7	12	16	12	
Number of Inefficiency	13	8	4	8	
Maximum Efficiency	104.9	100	100	100	
Minimum Efficiency	0.937	88.7	0.953	0.887	
Average Efficiency	0.998	0.971	0.993	0.979	

Notes: Technological change (TCHNCH), constant return to scale technical efficiency (CRS), variable return to scale technical efficiency (VRS), Constant return to scale (CRS), variable return to scale (VRS), Decision Making Unit, return to scale (RTS),

* Refer to Table 1 for the corresponding name of the banks

** CRSTE < 1, inefficiency is attributable to poor management

*** VRSTE < 1, inefficiency is attributable to problem in scale (use of resources)

Source: Authors' computation from DEAP v. 2.1 software

Table 5 reveals that seven (7) banks that are technologically efficient while 13 banks are inefficient. BDO, AUB, UOB and PB are technologically (TECHCH) and technically efficient based on their CRSTE/VRSTE assumptions. Four banks, namely, AUB, BDO, UOB, and PB, operated at a maximum capacity, where they achieved the most productive scale size (MPSS) of operation and updated technology (TCHNCH >1.00). At the MPSS, they are resource or cost efficient (CRS = 1.00), management efficient (VRS = 1.00), and were operating at an advantageous condition (scale = 1.00, the constant return to scale, CRS).

Under CRSTE assumptions, 12 banks are efficient while 8 banks are inefficient. Banks in this category which achieved a pure technical efficiency score of 1.0 and lie in the efficient frontier. As shown in Table 5, the results generated for the scale model are the same for CRSTE, which is computed as the quotient of the CRSTE and VRSTE. At their

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constant return to scale technical efficiency (CRSTE), they used 100% of the inputs and produced 100% outputs. This only proves that the 12 banks utilize their resources to optimize the use of inputs to generate the outputs provided Figure 1.

Under VRSTE assumption, sixteen banks (80%) were efficient, and four banks were inefficient. For the additional 12 banks that became efficient under the VRSTE assumption, their technical inefficiency did not come from poor utilization of resources but emanated from their operations from scale size. Three out of four inefficient banks under VRSTE assumption, namely PNB, CBC, and ABM, derived their technical inefficiency from both pure-technical (poor utilization of inputs) and scale inefficiencies. Only AB did not reflect managerial inefficiency. Aside from these four banks, under the scale model, BPI and MBT in the Philippines and RHB and CIMB in Malaysia were also inefficient, as they obtained scale scores < 1.

The three models, namely, CRSTE, VRSTE, and Scale, reflect the average efficiency scores of these banks for the period 2012-2018 as 97.1%, 99.3%, and 96.9%, respectively. Despite the low scores generated to achieve efficiency, on average, banks in the Philippines and Malaysia can improve their average technical efficiency (TEEFCF) by 2.9%, 0.7%, and 2.1%, correspondingly.

Overall, only 8 banks achieved technical inefficiency ranging from 3.2% to 11.3%, which was mainly driven by scale compared to managerial inefficiency. This moderate deviation from the efficient frontier is more evident among Malaysian banks than Philippine banks. Likewise, the results prove that only four (4) banks portrayed best practice among their peers and will continue to be efficient in all aspects of the total productivity measures except if there are changes in the economy, business activities, institutional underpinnings. Despite the technological inefficiency of RCBC, MBB, AMMB, OCBC, HLFG, UBP and PBC, they were able to achieve their technical efficiency.

Table 6 shows average technological efficiency, and average input and output slacks derived from the slack analysis for the DMUs in both countries. Seven banks are technologically efficient and the remaining 13 banks have average TECHCH <1, which means that they are technologically inefficient. For these banks, there is evidence of deviation from the best practice frontier related to their technological efficiencies.

Table 6. Output shortage and input surplus in Technological Efficiency of DMUs

		Output Variables (in 000)			Input Variables (in 000)			
Bank Name*	TCHNCH	Interest Income	Non-Interest Income	Net Loans	Interest Expense	Non-Interest Expense	Deposit Liabilities	Personnel Expense
Constant Return to Scale								
Efficiently Strong = Achieved Positive Technological Improvement								
AUB	1.049	0	0	0	0	0	0	0
BDO	1.027	0	0	0	0	0	0	0
UOB	1.019	0	0	0	0	0	0	0
PB	1.005	0	0	0	0	0	0	0
Decline in Technological Growth but Maintained								
RCBC	0.993	0	0	0	0	0	0	0
MBB	0.993	0	0	0	0	0	0	0
AMMB	0.993	0	0	0	0	0	0	0
OCBC	0.99	0	0	0	0	0	0	0
HLFG	0.97	0	0	0	0	0	0	0

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SBC	0.968	0	0	0	0	0	0	0
UBP	0.956	0	0	0	0	0	0	0
PBC	0.937	0	0	0	0	0	0	0
Decreasing Return to Scale								
Efficiently Weak = Improvement in Technological Growth								
BPI	1.009	0	0	0	0	0	0	0
Efficiently Weak = Decline in Technological Growth								
MBT	0.997	0	0	0	0	0	0	0
RHB	0.996	0	0	0	0	0	0	0
CIMB	0.995							
Technological efficient = Improvement in Technological Growth with Excess Resource Use								
PNB	1.043	0	0	0	0	1.6	0	0.46
CBC	1.021	0	0	0	0	1.2	25.3	0
Inefficient = Technological Obsolescence with Excess Resource Use								
AB	0.999	0	163	3,863.7	66.3	-	-	-
ABM	0.997	0	86	1,798.9	-	-	1,163.7	52.4

Notes: Technological Efficiency Change (TCHNCH)

* Refer to Table 1 for the corresponding name of the banks

Source: Authors' computation from DEAP v. 2.1 software

In this study, the authors divided the banks into six categories as shown in Table 6. Four banks (AUB, BDO, UOB, and PB) are efficiently strong with positive technological improvements. The second group, which accounted for 40% of the DMUs, consists of RCBC, MBB, AMMB, OCBC, HLFG, SBC, UBP, and PBC. Even if they generated TCHNCH <1.000, they still maintained the most productive scale size (MPSS) of operations. This is in line with the observation of Kamarudin *et al*. (2019) where they mentioned that banks should improve their performance by investing more on improvement in the skills of their employees, technologies, and their risk management skills.

Despite achieving technological efficiency, BPI experienced a decline in its returns to scale (TCHNCH>1.000 with DRS despite the zero (0) slacks in both the input and output variables. Unlike the fifth group which were also technologically efficient, they have excess inputs. The fourth group which exhibited a decline in technological growth consists of MBT, RHB, and CIMB. They do not have slack input and output. They may be efficient in the use of their resources but are technologically inefficient.

Banks (PNB & CBC) belonging to the fifth group are technologically efficient like the first and third groups, but they have excess inputs to produce the desired outputs. CBC generated excess deposits and incurred additional costs in interest expense while PNB also incurred costs of has USD 1.2 thousand excess in incurred generated low non-interest income and showed excess non-interest expenses and deposit liabilities. PNB also paid higher interest on deposit liabilities and higher personnel expense to generate the same outputs. The sixth group, comprising AB and ABM, were technologically inefficient and generated either slack outputs for the same input or slack input variables used in their intermediation activities. This means that these banks have slack outputs and are experiencing technological obsolescence. AB demonstrated a slack in outputs: non-interest income and net loans while having excess resource use in terms of interest expense. ABM showed slack in terms of non-interest income and net loans. There is an excess resource utilization (both in deposit liabilities and personnel expenses). This only proves that AB and ABM are incurring high intermediation and operating costs, and they are not able to generate more income from their operations.

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6. CONCLUSIONS AND RECOMMENDATIONS

This study examined the total factor productivity and efficiency of the top ten commercial banks operating the Philippines and Malaysia during the period 2011 to 2018 using financial data culled from the published annual reports. As there were limited studies that were conducted in the Philippines and Malaysia on efficiency, this study aimed to fill this gap. Analyzing the two groups of commercial banks and the decision-making unit's efficiency and productivity is the primary goal of this paper using Malmquist Productivity Index and slack-based measure in the Data Envelopment Analysis.

The volume of inputs and outputs of the DMUs are not correlated to their efficiency scores. While Malaysia had a substantial number of input and output variables compared to the Philippines, the latter consistently gained a TFPRCH score ≥1 grade where seven out of the eleven banks came from the Philippines and four from Malaysia. There is a great potential for Philippine banks to increase their efficiency. The authors believe that efficiency scores derived from technological and technical efficiencies, with the decomposition of the latter into scale and managerial efficiencies can provide practical insights and implications for banks and other financial institutions. Bank policymakers should consider how they can formulate plans and develop key strategies for introducing technological innovations to compete locally and internationally, considering that cross-border transactions are increasing and becoming part of their normal business operations.

Based on the results, five banks improved their technological efficiency (TECHCH) while the other five banks in the Philippines have declining trend. On the other hand, only two Malaysian banks scored well, namely PB and UOB. Overall, Philippine banks were more efficient by allocating a large portion of their financial resources in technology-related activities to provide responsive technology-driven services and products. This is understandable considering that clients preferred dealing with DMUs that invest in technological innovation and those that can use optimal mix of inputs to achieve desirable outputs in their core business activities compared to Malaysian banks. Operational efficiency is the primary driver of the commercial banks' overall productivity, and they should not only take advantage of the scale efficiency that they enjoy compared to small banks, and their administrative efficiency, especially in reducing operations costs related to human capital. Awareness of the bank's level of efficiency can help bank policymakers to leverage or effectively strategize to improve their operations and create products that will provide corresponding or greater outputs for the input resources that they put it to reach the efficient former. Likewise, knowing the target inputs and outputs and identifying the source of efficiency can also provide valuable inputs to banks to make substantial improvements on this competitive advantage.

All banks that were technically efficient were producing maximum outputs with the input that they provided. Only SBC and RHB are pure technical and scale inefficient. Both banks should improve their technologies, skills, and techniques to reach pure technical efficiency. Only CBC was scale inefficient and should improve its operations to be competitive. According to Banna *et al*. (2017), small commercial banks must expand to raise their efficiency level.

Only four banks showed slacks in selected input and output variables. Two are Philippine banks namely PNB and CBC, while two are Malaysian banks, namely, AB and ABM. This suggests that they should reduce their use of excess inputs and increase their outputs,

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to be efficient. The total factor productivity (TFPRCH) of Philippine banks were better compared to Malaysian banks. Most inefficiencies in TFPRCH were due to technological inefficiencies of banks. Therefore, banks should focus on technological advancements to yield better efficiency results.

Both the Philippine and Malaysian banks showed almost similar technical, pure technical and scale efficiency scores. They should consider other factors (e.g.: structure, changes in the pricing of the products and services) that can affect their efficiencies and should constantly monitor and improve their core banking to be more efficient and profitable. The authors recommend that other types of banks and quasi-banks must be aware of the changes in the efficiency scores of banks and learn from the experiences of these commercial banks to improve their performance and increase their profitability.

Comparing the banks from these countries, irrespective of its residents' religious affiliation or differences, is crucial, as banks follow international standards of best practices in banking. Bank policymakers from these countries can determine the best models to measure their efficiency performance and its sources and identify the optimal mix of input and output variables to reach the efficient frontier. Other banks in these countries and in other parts of the world, can learn from the findings from this study where information provided in this study can serve as a guide in constructing policies that will better suit the nature of the banking industry of each country. It can also help clients and investors understand the performances of the top ten commercial banks in the Philippines and Malaysia and make sound decisions in choosing the banks they will do business with. This study could help the researchers in undertaking more studies on the efficiency of banks and other financial institutions to become more competitive in the international market. Researchers can conduct future studies by expanding the sample size and including different ASEAN countries and diverse types of banks. One of the limitations of the study is its failure to incorporate the predictors of bank efficiency, such as the environmental factors, R & D activities, bank size, and other bank-specific indicators. Future studies can use logistic regression model to determine the impact of these predictors on bank efficiency in these countries or other countries The authors recommend that researchers investigate these determinants. They can also explore the use of other methodologies such as Stochastic Frontier Analysis, Machine Learning, and other mathematical and statistical tools.

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