

## The Efficiency Analysis of Domestic and Foreign Commercial Banks of Pakistan: The Data Envelopment Analysis Approach

**Farhat Ullah Khan**

Assistant Professor, Department of Business Administration, Gomal University, Dera Ismail Khan, KP, Pakistan.

Email: [farhatullahpk@gmail.com](mailto:farhatullahpk@gmail.com)

**Aziz Javed**

Assistant Professor, Department of Business Administration, Gomal University, Dera Ismail Khan, KP, Pakistan.

**Khalid Rehman**

Lecturer, Department of Business Administration, Gomal University, Dera Ismail Khan, KP, Pakistan.

### Abstract

*The aim of the present study is to investigate the efficiency of domestic and foreign commercial banks of Pakistan over the period from the year 2009 to 2013 through the DEA technique (Data envelopment analysis). DEA estimates efficiency by the ratio of inputs (multiple) to outputs (multiple). For this purpose, the number of employees, deposits and fixed assets were used as inputs while Advances and Investments were taken as the outputs based on the intermediation approach. Two generic forms of DEA explicitly CCR and*

*BCC were applied to work out technical and pure-technical efficiencies, respectively. Results offered significant information to make the decision about the efficiency of commercial banks. The study outcomes showed that foreign-owned banks performed better against public and private-owned banks in respect of all the efficiency measures throughout the period of study.*

### Key Words

Efficiency, Domestic Banks,  
Foreign Banks, Commercial Banks,  
Data Envelopment Analysis

### Introduction

Financial organizations across the world underwent significant changes due to Industrial progress, easy access to information, intense competition, and continuous deregulation. The emergence of a fast-paced, dynamic environment in the banking industry has heightened the significance of efficiency, particularly after financial deregulation and structural reforms. These reforms created and fostered the competition among domestic and foreign banks to meet ever-changing customer/consumer needs by introducing new and innovative products. It is recognized that the higher the degree of competition, the firms would need to become more efficient to grow and survive. In a competitive marketplace, banking organizations carry on their endeavors to meet new challenges through efficiency improvement in their operations (Khan, Ali, & Khan, 2018).

The banking system is thought to be the lifeblood for modern-day business as it acts as a core source for financial intermediation. In this connection, the significance of the banking sector, in its capacity of financial intermediation, facilitates the economic activities in the country. Thus, evaluating financial conditions and performance of the banking sector during past decades become an issue of considerable importance, particularly in developing countries like Pakistan (Abbas, Azid, & Besar, 2016). The banking organizations are now more worried to assess their relative efficiency against their rivals under the current competitive environment. The most common methods for efficiency analysis are stochastic frontier and regression analysis. However, these methods may provide an inappropriate picture due to the inability to handle several inputs and outputs combinations generated by the banking institutions.

Data Envelopment Analysis (DEA) offers an apparent source of calculating levels of efficiency within a group of organizations. In DEA, the efficiency of an organization is computed relative to best practices observed by the group. It typically uses linear programming techniques to examine the efficiency of an organization by linking to best practice organizations within a group. The efficiency so computed is commonly denoted to as “technical efficiency”. It is described as the ability of an organization to transform its input resources, under given technology, into outputs relative to best practice organization”. The organization which preserves the wastage of input resources and produces the assumed level of output is named as technically efficient and labeled as a best-practice organization (Titko, Stankevičienė, & Lāce, 2014).

The significant position of banks in economic advancement is established among academia, researchers, investors, and stakeholders. The banking institutions contribute to the overall prosperity of

A country by allocating capital for productive uses, finances for infrastructure and innovation accelerating funds flow for investments purpose, generating employment opportunities in the economy and at the same time, acting as a primary tool for implementing the fiscal policy of the government. Due to banks' fragile nature, it is essential to regularly monitor the financial performance of banking organizations. The analysis can be helpful to identify, at an early stage, the potential problems which exist in the banking industry. This diagnosis can provide an opportunity to take timely remedial actions to save the economic system of the country from financial distress. It can also signal the impact of a bank's operational policies on its performance (Majeed & Zanib, 2016).

## **Objective of Study**

The economists from around the world showed keen interest in appraising the banks' financial performance because of their dominant position in the economy. Most of them focused on the financial performance of banks from the US and other developed economies. For developing countries, limited studies are available concentrating on banks' performance. Therefore, the present research is an effort to fill up the literature gap by probing the efficiency of domestic and foreign banks of Pakistan as a financial performance measure and to get an insight about the banks' "ownership structure" of Pakistan. The Pakistani ownership structure of the banks changed substantially after the financial reforms of the 1990s, which resulted in decreasing the share of state-owned (Public sector) banks substantially. As a result, the foreign-owned banks were granted licenses to operate in Pakistan along with domestic banks under the same regulatory environment. This led the domestic banks in direct competition with the foreign banks. Therefore, this study specifically measures domestic versus foreign commercial banks technical efficiencies. Further, the study also computes scale and pure technical efficiencies to assess managerial capabilities and economic scale size of both ownership groups of banks operating in Pakistan.

## **Literature Review**

The efficiency analysis of banking institutions across different ownership groups has been studied by many researchers in the presence of home ground theory and global advantage theory suggested by "Berger, DeYoung, Genay, and Udell (2000)". The former theory assumes that domestic or local institutions are usually, to a greater extent, efficient than foreign banks. Because they possess a better knowledge of local conditions, environment, market, easy adjustment to local culture and language, economies of scale (diseconomy in monitoring its subsidiary from a distance), and absence of structural agency costs. This theory was tested by (Jemric & Vujcic, 2002) by examining the efficiencies of the domestic and foreign banking institutions in Croatia by "DEA". The study came up with the conclusion that foreign or overseas banks are more technically efficient as opposed to domestic or local banking firms. Similarly, Kraft, Hofler, and Payne (2006) analyzed the Croatian banks cost-efficiency through a stochastic frontier approach (SFA) and found that foreign banks are even greater advantageous concerning cost efficiency than domestic banks. Similar findings were obtained by Havrylychuk (2006), and Asaftei and Kumbhakar (2008).

Whereas from the angle of global advantage theory, the foreign-owned perform better than domestic owned because of top-quality management, higher liquidity, offering capital at low cost, add-on skills to manage risks, latest technology, wider knowledge of international or global markets, a wide variety of products and services as well as more expertise in investment management. This hypothesis is found accurate in the context of developing nations, while the opposite is factual in developed nations. The studies which confirm the hypothesis are Turk Ariss (2008), Kyj and Isik (2008), and Albayrak (2009). However, few studies in Pakistan that also validates the hypothesis are Qayyum and Khan (2007), Ansari (2006), and Burki and Niazi (2010). Keeping in view the above, the present study makes an effort to examine the efficiency disparities among foreign and domestic commercial banks of Pakistan. In recent years, the difference in efficiency across banks belonging to diverse ownership has attracted the researchers as an important area to focus on.

## **Methodology**

The theory of efficiency had perhaps existed since the day humanity initially settled in the old African continent for purposes of hunting. During hunting expeditions, they gradually realized that more animals (outputs) could be hunted by combining their resources (inputs) jointly than as individuals. Thus, joint efforts of individuals led to the use of resources like hunting tools (capital investments) and labor (inputs) more efficiently. The efficiency at the basic level is "doing things the right way". The more precise definition is increasing the required productivity with allotted resources. However, the standard definition is the "ratio of output (s) to input (s)". According to this definition, the main task at hand would be to define the desired outputs and the inputs required to produce such

outputs of a firm under analysis. Once the input and output identification process are complete, the next job is to examine how these inputs interact with each other to produce outputs in a group of firms (Avkiran, 2006).

The process is executed to discover inefficiencies in the provision and transformation of resources into outputs. This measure of efficiency is generally described as relative efficiency. The ratio equals 1 or 100% under this measure indicates an efficient firm and less than 1 describes the firm under analysis as inefficient. It means that the efficient firm is the one that can smartly and cleverly use input resources rather than working for extended hours. The question crops up in mind as to why relative efficiency needs to be studied. Two key arguments are there in its validation. The first, highly realistic justification is the identification of the gap contained by the hypothetical expectations of full efficiency and practical truth. Secondly, if there is technical inefficiency, there is a good chance that it will have an impact on the effectiveness of the allocation and will harm overall economic effectiveness. According to this logic, the analysis of technical efficiency is central to the economic performance of a firm. The historical roots of measuring technical efficiency date back to works of the Farrell, (1957), Debreu (1951) and Koopmans (1951).

The efficiency of financial institutions can be assessed by the non-parametric and parametric styles. Sharma, Sharma, and Barua (2013) surveyed in 2013, pointing out that three parametric and two approaches (non-parametric) are typically used to calculate financial institutions efficiency. Three much-practised parametric methods are TFA (thick frontier approach), DFA (distribution-free approach), and SFA (stochastic frontier approach). On the other hand, two approaches (non-parametric) of FDH (free disposal hull) and DEA (data envelopment analysis) are mainly used in banking literature to measure efficiency. It is hard to decide which of the above main approaches is better because each approach has its advantages and disadvantages. The parametric methods require to postulate the connection among outputs and inputs through a predefined function that determines the efficiency frontier. The efficiency results thus obtained may be distorted if the functional shape is not properly specified. On the other hand, specification of such form or shape is not mandatory under non-parametric approaches.

DEA and SFA are mostly used in the banking literature. The former is, however, preferred over later due to its unique characteristics. First, DEA does not need the predefined function to describe the unknown association amid inputs and outputs or the distribution of random error which may cause potential specification error. Secondly, the predefined weights of inputs and outputs are not required to be assigned under DEA. Thirdly, small sample sizes can be easily handled with DEA compared to SFA. Last but not least, it can, simultaneously, handle several inputs and outputs. Hence, this study used DEA to gauge the commercial banks' efficiency of Pakistan based on their ownership.

There are two basic or generic models of DEA. The first basic DEA model to measure technical efficiency was introduced under the theory of CRS (Constant Return to Scale) (Charnes, Cooper & Rhodes, 1978). The theory was later on expanded the basic DEA model by “dividing the technical efficiency” into scale efficiency and pure technical efficiency (Later, Banker, Charnes, & Cooper, 1984). Both DEA models can measure efficiency under input and output orientation. The input-orientated approach focuses on how to minimize the input resources to obtain a given level of outputs, and the output-orientated approach measures efficiency by how to increase the outputs using fixed inputs.

The dual linear mathematical formulation for CCR and BCC models of DEA are given below:

<b>“Input oriented CCR-Model.”</b>	<b>“Input oriented BCC Model.’</b>
<i>minimize</i> $\theta_0 = \text{Technical Efficiency}$	<i>minimize</i> $\theta_0 = \text{Pure Technical Efficiency}$
Subject to	Subject to
$\sum_{j=1}^n \lambda_j x_{ij} \leq \theta_0 x_{i0} \quad , \quad i = 1, 2, \dots, \dots, m;$	$\sum_{j=1}^n \lambda_j x_{ij} \leq \theta_0 x_{i0} \quad , \quad i = 1, 2, \dots, \dots, m;$
$\sum_{j=1}^n \lambda_j y_{rj} \geq y_{r0} \quad , \quad r = 1, 2, \dots, \dots, s;$	$\sum_{j=1}^n \lambda_j y_{rj} \geq y_{r0} \quad , \quad r = 1, 2, \dots, \dots, s;$
$\lambda_j \geq 0$	$\lambda_j \geq 0$
	$\sum_{j=1}^n \lambda_j = 1$

where  $\theta_0$  in the above represents the efficiency of the DMU (decision-making unit) and in the present study, the DMU represents a bank for which efficiency is to be computed. The value of  $\theta_0 = 1$  for bank “o” to be evaluated indicates efficiency under both models and value of  $\theta_0 < 1$  shows an inefficient bank. The efficiency measure  $\theta_0$  is

computed under the input constraints ( $\sum_{j=1}^n \lambda_j x_{ij} \leq \theta_0 x_{io}$ ) and output constraints ( $\sum_{j=1}^n \lambda_j y_{rj} \geq y_{ro}$ ). Where  $\sum_{j=1}^n \lambda_j x_{ij}$  represents weighted ( $\lambda_j$ ) inputs  $x_{ij}$  of  $j^{\text{th}}$  banks and  $\theta_0 x_{io}$  is efficiency times inputs of bank “o” understudy. Similarly, expression ( $\sum_{j=1}^n \lambda_j y_{rj}$ ) represents weighted outputs of all banks in sample and  $y_{ro}$  is the output of the bank “o”. The constraint  $\lambda_j \geq 0$  indicates  $j$ th weights of inputs and outputs of all the banks in the sample to be strictly non-negative. The presence of constraint  $\sum_{j=1}^n \lambda_j = 1$  in the BCC model indicates a variable return to “scale assumption” to be equal to 1.

**Specification of Inputs and Outputs**

The DEA models require input-output variables to be defined for the computation of efficiency. There are two approaches widely used to select inputs and outputs. One such measure is commonly known as the production approach, which assumes the DMU (bank) as a production unit that produces single or multiple outputs with multiple inputs. The other approach called the intermediation method deems banks as an intermediary between supplier and users of funds. The banking literature provides that the intermediation method is more suited to measure efficiency level banks, while production method is considered proper in the case of efficiency evaluation of bank branches. Consequently, the current study used the intermediation method to select inputs-output variables. The inputs adopted are the number of employees as a proxy for Labour, fixed assets net of depreciation to signify physical capital, and deposits to indicate loanable funds. The output variables are the Advances net of provisions and investments.

**Sample and Period of Study**

The banks are the dominant segment of Pakistan financial sector due to its principal share in financial assets. The banking sector of Pakistan comprises thirty-four (34) commercial banks and four (04) specialized banks (development financial institutions) as per quarterly performance review 2015 of “State Bank of Pakistan (www.sbp.org.pk)”. The commercial banks include five (5) Public-sector, twenty-two (22) private owned, and seven (7) foreign-owned banks. The current study took a sample of thirty-one (31) commercial banks comprising of 22 private sectors, 04 public sector banks, and 05 foreign-owned banks based on the availability of data from period 2009 to 2013, the tenure of the first democratic government since military rule from the year 1999.

**Results and Discussion**

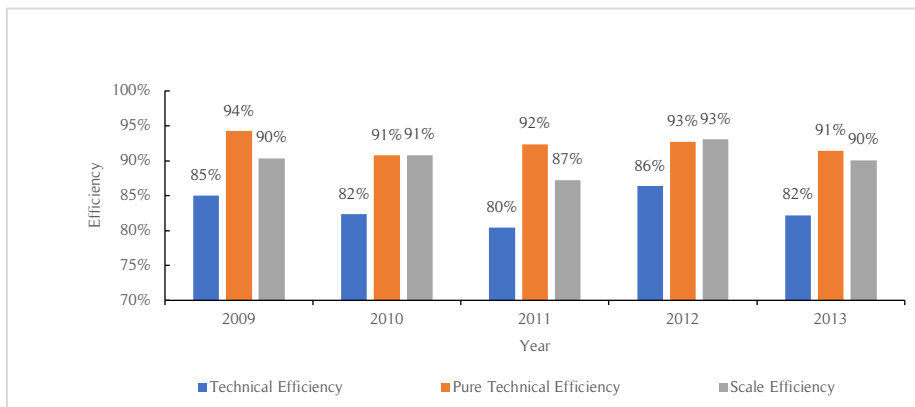
**Efficiency Results of Overall Commercial Banks**

Table 1 presents the annual average technical, scale efficiencies and purely technical, of 31 Pakistan commercial banks over period 2009-2013 along with standard deviation, minimum, and maximum DEA scores.

**Table 1.** Scale Efficiency, Pure Technical Efficiency, and Technical Efficiency, of Pakistani Commercial Banks: Period 2009 to 2013

	Technical Efficiency					
	2009	2010	2011	2012	2013	2009-13
Mean	0.85	0.82	0.80	0.86	0.82	0.83
Std. Dev	0.11	0.12	0.12	0.12	0.13	0.12
Min.	0.59	0.64	0.54	0.56	0.54	0.54
Max	1.00	1.00	1.00	1.00	1.00	1.00
N	31	31	31	31	31	31
Pure Technical Efficiency						
	2009	2010	2011	2012	2013	2009-13
Mean	0.94	0.91	0.92	0.93	0.91	0.92
Std. Dev	0.09	0.09	0.10	0.10	0.12	0.10
Max.	1.00	1.00	1.00	1.00	1.00	1.00
Min.	0.64	0.70	0.67	0.68	0.55	0.55
N	31	31	31	31	31	31
Scale Efficiency						
	2009	2010	2011	2012	2013	2009-13
Mean	0.90	0.91	0.87	0.93	0.90	0.90
Std. Dev	0.09	0.09	0.10	0.07	0.08	0.09
Max.	1.00	1.00	1.00	1.00	1.00	1.00
Min.	0.71	0.71	0.71	0.78	0.73	0.71
N	31	31	31	31	31	31

The mean technical efficiency (TE) based on the annual frontier is 83% leaving an inefficiency gap of 17%. It means that the commercial banks of Pakistan may have generated the equivalent outputs by 17% fewer inputs than currently used. The yearly technical efficiency scores exhibit a mixed trend over the study period. To explore the reasons behind this inefficiency gap, the TE is decomposed further into SE (scale efficiency) and PTE (pure technical efficiency) measures. The PTE deals the managerial competency and simply is the TE without scale effect. The average PTE stays at 92% throughout the study with inefficiency of only 8%. The difference between TE and PTE shows that the firm (or bank in the current study) is operating at an uneconomical scale size. The SE is measured by “ratio of TE to PTE”. The mean SE over the period from 2009 to 2013 is 90% indicating an inefficiency of 10%. The comparison of PTE and SE leads to a conclusion that commercial banks technical inefficiency of Pakistan is caused more by scale inefficiency compared to purely technical or managerial inefficiency. Similar results have been reported by Tamatam, Dutta, Dutta, and Lessmann (2019), Ismail, Shabri Abd. Majid, and Rahim Rossazana (2013) and F. U. Khan and Khattak (2016).



**Figure 1:** Technical, Pure- Technical, and Scale Efficiencies of Commercial banks: (Period 2009-2013)

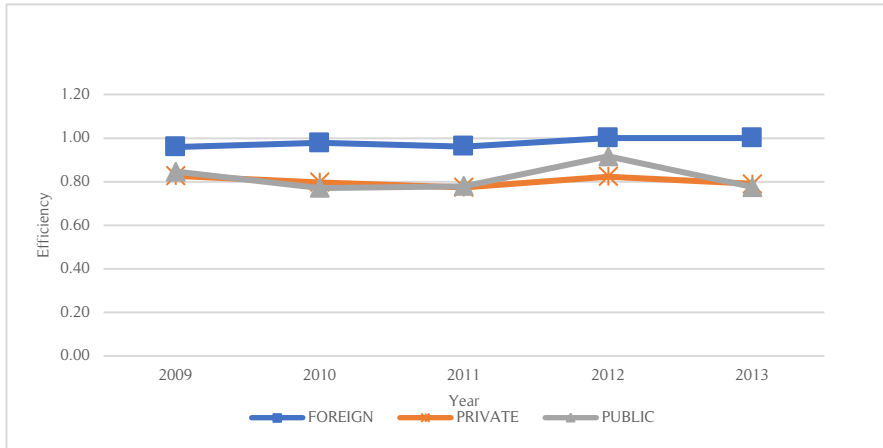
### Efficiency Results by Ownership

The analysis of efficiency parameters across various ownership groups (private, public & foreign banks) is vital for bank owners, prospective investors, and regulators. Even Though these banks work in the same banking regulatory background, yet they may perhaps experience distinct performance due to varying degrees of managerial skills, practices, natures of business, and government sponsorship. The average efficiency scores of commercial banks split into three groups based on their proprietorship (private-public & foreign) are provided in table 2.

**Table 2.** The efficiency of Commercial Banks Based on the Ownership Group

Efficiency	Year	Foreign	Private	Public
TE	2009	0.96	0.83	0.85
	2010	0.98	0.80	0.77
	2011	0.96	0.77	0.78
	2012	1.00	0.82	0.92
	2013	1.00	0.79	0.77
	Mean		0.98	0.80
PTE	2009	1.00	0.92	0.99
	2010	0.98	0.89	0.91
	2011	0.98	0.91	0.92
	2012	1.00	0.90	1.00
	2013	1.00	0.90	0.90
	Mean		0.99	0.90
SE	2009	0.96	0.90	0.85
	2010	1.00	0.90	0.86
	2011	0.98	0.85	0.85
	2012	1.00	0.92	0.92
	2013	1.00	0.88	0.88
	Mean		0.99	0.89

The efficiency analysis across three ownership reveals that the foreign banks seem to be technically more “efficient than on average” as well as yearly scores compared to their counterparts. Whereas the public sector “banks on average seem” to be efficient more than private-owned banks of Pakistan. The foreign, private, and public sector banks mean TE scores stood at 98%, 80%, and 82% respectively. It implies that foreign, private, and public sector banks might have generated the same actual outputs with 2%, 10%, and 8% less of current inputs used, respectively.

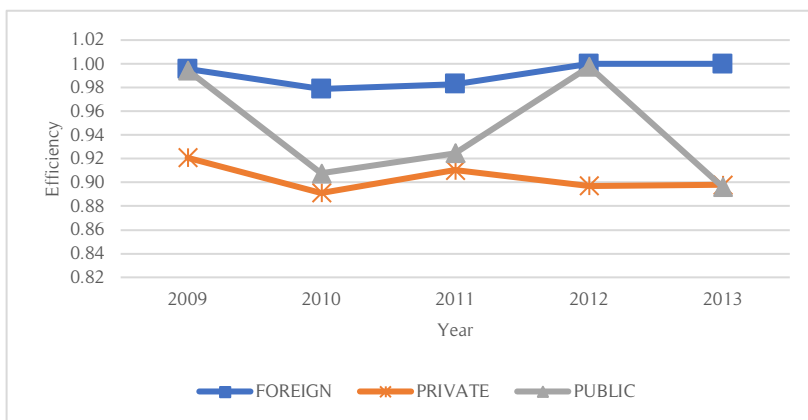


**Figure 2:** Technical Efficiency of Private, Public and Foreign Banks: Period (2009-2013)

Source: Author's Elaboration.

### Pure Technical Efficiency of Public, Private & Foreign Banks

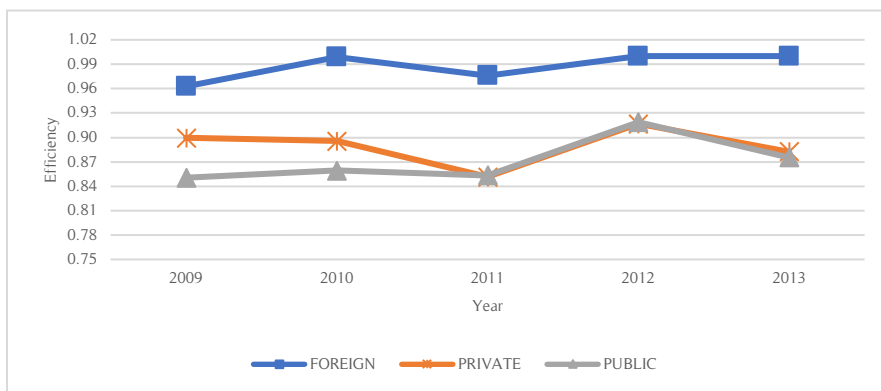
The TE is further decomposed into PTE and SE to identify the level of managerial expertise and the impact of the size of operations, respectively. The pictorial display of pure technical efficiency from the year 2009 to the year 2013 can be viewed in figure 3 extracted from table 2. The foreign banks outclassed their counterparts' banks from the public and private sectors throughout the study period. It implies that foreign banks possess better managerial competence over their rivals in converting their inputs into outputs during the intermediation process. The figure further reveals that the public sector is better in terms of pure technical efficiency than private sector banks.



**Figure 3:** Pure Technical Efficiency of Private, Public & Foreign Banks: Period (2009-2013) Source: Author's Elaboration.

### Scale Efficiency of Public, Private & Foreign Banks

The second component of TE is SE which measures the capability of a bank to become efficient by operating at the most economical size. The scale efficiency is depicted graphically as well as tabulated in figure 4 and table 2, respectively. It is quite evident that foreign-owned are consistently far better than private and public over the whole study period from 2009 to 2013. The above findings validate the hypothesis “that foreign banks” are efficient more than public and private ownership for all components of efficiency. These findings can be compared to the study by Novickýtė and Drożdż (2018).



**Figure 4:** Scale Efficiency of Public, Private, and Foreign Banks: Period (2009-2013)  
*Source: Author's elaboration.*

## Conclusion

The present study evaluated the performance of 31 commercial banks belonging to the foreign, private, and public sectors during the first democratic period after the military rule in Pakistan from the year 2009 to 2013. DEA was employed to assess the technical, Pure-Technical, and scale efficiencies. It uses inputs and output variables to compute efficiency parameters. The inputs and outputs were carefully chosen through “intermediation approach” applied in banking literature. The study used the Number of employees, Deposits and fixed assets, were used as a proxy for input variables while Advances and investments have opted as output variables. Technical efficiency was estimated by DEA (CCR model), Pure-technical efficiency by the Scale Efficiency and BCC model by the ratio of TE to PTE. The findings of these models showed that on average, the commercial banks of Pakistan operated at 83%, 92%, and 90% in terms of SE, PTE, and TE, respectively. The major cause behind the technical inefficiency was scale inefficiency. The efficiency results of commercial banks were further classified into three groups of Foreign, private, and public sector banks based on ownership structure. It was revealed that foreign banks outperformed their competitors in terms of all efficiency parameters over the period 2009 to 2013. This study, therefore, validates the hypothesis that foreign banks are efficient more associated with public and private sector banks in Pakistan.

## References

- Abbas, M., Azid, T., & Besar, M. H. A. H. (2016). Efficiency, effectiveness, and performance profile of Islamic and conventional banks in Pakistan. *Humanomics*.
- Albayrak, A. S. (2009). Classification of domestic and foreign commercial banks in turkey based on financial efficiency: a comparison of decision tree, logistic regression, and discriminant analysis models. *Suleyman Demirel University Journal of Faculty of Economics & Administrative Sciences*, 14(2).
- Ansari, M. S. (2006). An empirical investigation of cost efficiency in the banking sector of Pakistan: State Bank of Pakistan.
- Asaftei, G., & Kumbhakar, S. C. (2008). Regulation and efficiency in transition: the case of Romanian banks. *Journal of Regulatory Economics*, 33(3), 253-282.
- Avkiran, N. K. (2006). Productivity analysis in the service sector with data envelopment analysis. Available at SSRN 2627576.
- Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management science*, 30(9), 1078-1092.
- Berger, A. N., DeYoung, R., Genay, H., & Udell, G. F. (2000). Globalization of financial institutions: Evidence from cross-border banking performance. *Brookings-Wharton papers on financial services*, 2000(1), 23-120.
- Burki, A. A., & Niazi, G. (2010). Impact of financial reforms on efficiency of state-owned, private and foreign banks in Pakistan. *Applied Economics*, 42(24), 3147-3160.
- Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European journal of operational research*, 2(6), 429-444.
- Debreu, G. (1951). The coefficient of resource utilization. *Econometrica: Journal of the Econometric Society*, 273-292.
- Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society: Series A (General)*, 120(3), 253-281.
- Havrylychuk, O. (2006). Efficiency of the Polish banking industry: Foreign versus domestic banks. *Journal of Banking & Finance*, 30(7), 1975-1996.
- Ismail, F., Shabri, A., Majid, M., & Rahim Rossazana, A. (2013). Efficiency of Islamic and conventional banks in Malaysia. *Journal of Financial Reporting and Accounting*, 11(1), 92-107. doi:10.1108/JFRA-03-2013-0011
- Jemric, I., & Vujcic, B. (2002). Efficiency of banks in Croatia: A DEA approach. *Comparative Economic Studies*, 44(2-3), 169-193.
- Khan, F. U., & Khattak, B. K. (2016). An empirical investigation of commercial banks' efficiency in Pakistan: a non parametric data envelopment approach. *Gomal University Journal of Research*, 32(1), 21-32.
- Khan, I. U., Ali, S., & Khan, H. N. (2018). Market concentration, risk-taking, and efficiency of commercial banks in Pakistan: An application of the two-stage double bootstrap DEA. *Business and Economic Review*, 10(2), 65-95.
- Koopmans, T. C. (1951). Efficient allocation of resources. *Econometrica: Journal of the Econometric Society*, 455-465.
- Kraft, E., Hoffer, R., & Payne, J. (2006). Privatization, foreign bank entry and bank efficiency in Croatia: a Fourier-flexible function stochastic cost frontier analysis. *Applied Economics*, 38(17), 2075-2088.
- Kyj, L., & Isik, I. (2008). Bank x-efficiency in Ukraine: An analysis of service characteristics and ownership. *Journal of Economics and Business*, 60(4), 369-393.
- Majeed, M. T., & Zanib, A. (2016). Efficiency analysis of Islamic banks in Pakistan. *Humanomics*.
- Novickytė, L., & Drożdż, J. (2018). Measuring the efficiency in the Lithuanian banking sector: The DEA application. *International Journal of Financial Studies*, 6(2), 37.
- Qayyum, A., & Khan, S. (2007). X-efficiency, scale economies, technological progress and competition: a case of banking sector in Pakistan.
- Sharma, D., Sharma, A. K., & Barua, M. K. (2013). Efficiency and productivity of banking sector. *Qualitative Research in Financial Markets*.
- Tamatam, R., Dutta, P., Dutta, G., & Lessmann, S. (2019). Efficiency analysis of Indian banking industry over the period 2008–2017 using data envelopment analysis. *Benchmarking: An International Journal*.
- Titko, J., Stankevičienė, J., & Lāce, N. (2014). Measuring bank efficiency: DEA application. *Technological and Economic Development of Economy*, 20(4), 739-757.
- Turk Ariss, R. (2008). Financial liberalization and bank efficiency: evidence from post-war Lebanon. *Applied Financial Economics*, 18(11), 931-946.