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Innovation and Bank Efficiency in Vietnam and Pakistan

Tien Phat Pham

Tomas Bata University in Zlin, Faculty of Management and Economics, The Czech Republic

Can Tho University, School of Economics, Vietnam

Boris Popesko

Tomas Bata University in Zlin, Faculty of Management and Economics, The Czech Republic

Abdul Quddus

Tomas Bata University in Zlin, Faculty of Management and Economics, The Czech Republic

Ny Thi Kieu Nguyen

Agribank Tien Giang, Vietnam

Abstract

The study investigates the effect of innovation on bank efficiency and the difference in efficiency between Vietnam and Pakistan banks. The balanced panel data from 23 banks (7 banks in Vietnam and 16 banks in Pakistan) in 2011-2019 is aggregated from the State Bank of Pakistan, the Vietstock, the MorningStar, the World Bank, and the website of banks. The quantitative models' estimation result is processed by the Pooled, the Fixed-effect, the Random-effect, and the Generalized Least Square approach, and confirmed again by the Tobit and T-test approach. The outcomes gave that innovation is the negative factor of bank efficiency. With or without the effect of innovation, the bank's efficiency in Vietnam is still lower than in Pakistan. The finding indicates that bank efficiency can be enhanced by increasing bank size instead of innovation, and bank age is the barrier to utilizing innovation for enhancing bank efficiency. Moreover, we found the bank's efficiency in Vietnam can be improved more quickly than in Pakistan by increasing bank assets. The macroeconomic condition is favorable for bank efficiency in both countries.

Keywords

Innovation, Bank Efficiency, Data Envelopment Analysis, Vietnam, Pakistan

JEL Classification

G20, G21

Introduction

Bank efficiency has attracted a vast of scholars, and there are many factors of bank efficiency. For example, Phan et al. (2016) gave the effect of market concentration and bank competition on bank efficiency, Luo et al. (2016) studied the effect of financial openness and bank risk on bank efficiency, and Nguyen (2018) indicated the effect of the diversification factor on bank efficiency. Innovation is also the determinant factor of bank efficiency (Wang et al., 2020, Frei et al., 1997). In the digital era, innovation plays the most crucial role in the finance sector. It is described by the rise of the fintech industry (Das, 2019) and the rise of financial institutions' technology investment (Gunawan & Serlyna, 2018, Beccalli, 2007). However, Liu et al. (2020) and Ardizzi et al. (2019) indicated that the bank's relationship between innovation and efficiency is not explicit. Liu et al. (2020) found evidence of the effect of innovation on efficiency in successful banks (high profit, high market share) and did not find evidence in other kinds of banks. Ardizzi et al. (2019) gave that innovation did not affect bank cost efficiency. Therefore, we argue that the concern about the role of innovation in bank efficiency needs to be clarified, which is also the study's primary aim.

The cross-country evidence shows that the bank efficiency field is various. Nguyen (2018) used the data from the banks of ASEAN countries (Vietnam, Cambodia, Indonesia, Malaysia, the Philippines, and Thailand) for investigating the relationship between diversification and bank efficiency. The results gave that funding-diversified and asset-diversified lead to enhance bank efficiency. Luo et al. (2016) collected data from 140 countries for investigating the cross-country differences of bank efficiency, financial openness, and risk. The authors revealed that financial openness was the indirect factor of increasing bank risk and reducing bank efficiency. Pasiouras et

Corresponding author:
Tien Phat Pham, Address: Mostní 5139, 760 01 Zlín, The Czech Republic
Email: tien@utb.cz, and phamphattien@gmail.com

al. (2009) found evidence of the positive impact of banking regulation on 615 commercial banks' efficiency in 74 countries from 2000 to 2004. The evidence from the emerging markets showed a positive relationship between bank mergers and acquisitions (M&A) and bank efficiency (Du & Sim, 2016). The national policy was the factor of cross-country differences in bank efficiency (Carbó Valverde et al., 2007). Moreover, Ngo and Le (2019) indicated the negative effect of the capital market size on bank efficiency. The bank in the larger capital market was less efficient than in the smaller market. To our best knowledge, the link between innovation and bank efficiency between countries seems to be missed by scholars. We consider that the conduct about this relationship at the cross-country is necessary, and the outcomes will be meaningful for bank managers and policymakers.

Vietnam and Pakistan are Asian developing countries whose economies have been the transition with the more significant connection to the world economy and the larger role of innovation (Saleem et al., 2019, Nguyen et al., 2018, Gërguri-Rashiti et al., 2017). McNulty et al. (2007) and Hermes and Lensink (2000) stated that the financial system and financial intermediation play a crucial role in the transitional economy. According to the World Bank data, we found that Vietnam and Pakistan's financial indicators are different; we could not determine which bank is more efficient. For example, in 2019, the number of automatic teller machine per 100,000 adults in Vietnam is 25.904 compares to 10.844 in Pakistan; while commercial bank branches per 100,000 population in Vietnam is 3.983, in Pakistan is 10.408; and in 2018, the ratio of non-performing loans in Vietnam and Pakistan is 1.804% and 7.974%, respectively. Thus, we toward to choose Vietnam and Pakistan for conducting the study, which is the effect of innovation on bank efficiency in Vietnam and Pakistan.

Literature Review

The determinant of bank efficiency

Cheruiyot (2017) and Faruq and Yi (2010) indicated that firm efficiency is influenced by firm age, firm size, firm location, and firm industry. Ramanathan et al. (2018) revealed the impact of innovation on firm efficiency, while Kapelko and Lansink (2015) stated that macroeconomic conditions facilitate increasing firm efficiency. In the finance sector, using the data of six emerging economics consist of Bangladesh, India, Indonesia, Malaysia, Philippines, and Vietnam, Phan et al. (2016) indicated that bank size, macroeconomic, and market concentration were favorable to bank efficiency, while competition and liquidity risk are negative. Tamatam et al. (2019) used the panel data of 38 Indian banks from 2008 to 2017. The result revealed that the ownership and the size were the significant factors of bank efficiency, and bank technological progress was a positive factor of bank efficiency improvement. Consequently, bank size, macroeconomic, market, competition, liquidity, ownership, and technology are the factors of bank efficiency.

Innovation and bank efficiency

Innovation, expressed by the research and development (R&D) activities, is the critical factor of firm competitiveness and firm survival (Zhang et al., 2018). Rajapathirana and Hui (2018) indicated there is a positive relationship between firm efficiency and firm innovation. In the banking industry, innovation plays a crucial importance in increasing bank efficiency (Frei et al., 1997, Wang et al., 2020). In the digital era 4.0, the rise of fintech brings both opportunities and threats for the bank. However, Klus et al. (2019) and Holotiuk et al. (2018) proposed that the bank and fintech company's innovation cooperation might improve bank efficiency. However, we argue that the increased efficiency by the innovation of bank-self is more critical than cooperating with the fintech company. Therefore, in this study, we limit the scope of innovation is just the R&D activities. We argue that the bank's increased efficiency is conducted from the innovation factor in the finance sector's competitive environment, which is the bank’s motive.

Cross-country of bank efficiency

The national business environment's effect on bank efficiency was different from countries (Carbó Valverde et al., 2007). Ngo and Le (2019) gave that bank efficiency was influenced by the capital market; namely, the larger capital market was less affected by bank efficiency than the smaller capital market. The authors also revealed that the development of the capital market was favorable to bank efficiency. Additionally, based on the results of Pasiouras et al. (2009), Luo et al. (2016), Nguyen (2018), and Du and Sim (2016), we can give that there is a difference in efficiency between the banks in countries.

Pakistan is a Muslim country; thus, besides national law and international regulation standards, the bank in Pakistan must follow Muslim rules. Vietnam is a nation of various religions; thus, the Vietnam bank must not meet any religious rules. Additionally, we consider a difference in capital market size between Vietnam and Pakistan, represented by the stock market size. The broad of Bloomberg.com gives that the size of the Vietnam stock market is smaller than that of the Pakistan stock market. Therefore, we discuss that the discipline of Muslims and Pakistan's large capital market is the cause of the difference in bank efficiency between the two countries. We argue that the efficiency of the bank in Pakistan is higher than in Vietnam.

Methodology

Research quantitative model

To investigate the effect of innovation on bank efficiency, we formulate the panel model as below:

$$Y_{it} = \propto + \beta X_{it} + \gamma Z_{it} + \varepsilon_{it} \quad (1)$$

where
Y_{it} is the bank efficiency variable of bank i at the time t,
X_{it} is the innovation variables of bank i at the time t,
Z_{it} is the control variables of bank i at the time t,
$\propto$ is the constant,
β is the coefficient of innovation variables,
γ is the coefficient of control variables,
μ_i is the bank effect to cover the specific heterogeneity,
δ_{it} is time-varying across banks and over time.

According to Wooldridge (2001), Hansen (1982), and Arellano and Bond (1991), we apply the Pooled, Fixed-effect approach (FE) and the Random-effect approach (RE) to estimate the regression model (1). The Pooled approach considers all observation as cross-section data, while both time-series and cross-section components are considered simultaneously by FE and RE. The Hausman test is used for choosing a suitable estimation result between FE and RE. Gujarati and Porter (2009) gave that the estimation result of the FE or RE might have the heteroskedasticity and/or autocorrelation issues, thus, we strategy to use the Wald test for investigating the heteroskedasticity, and Wooldridge test, and the Breusch and Lagrangian test for investigating the autocorrelation. If the estimation result of FE or RE has the heteroskedasticity or/and the autocorrelation issue, we will use the Generalized Least Square (GLS) to overcome the issues, it is suitable to the suggestion of Gujarati and Porter (2009) and Kamarudin et al. (2019).

In this study, the bank efficiency is calculated by the data envelopment analysis approach (Charnes et al., 1978), which leads to the value of bank efficiency is from zero (0) to (1). Thus, we use the Tobit model for the robustness check of the estimation results using the Pooled, FE, RE, and GLS approach (Faruq & Yi, 2010, Bremmera et al., 2008). Furthermore, besides investigating the cross-country variables as the explanatory variable in the regression model, we also use the T-test for estimating the difference between bank efficiency between Vietnam and Pakistan.

Measurement variables

The bank efficiency variable

The data envelopment analysis (DEA) has been popular in measuring firm efficiency since it was first published by Charnes et al. (1978). The DEA equation as below calculates the efficiency of the decision-making unit (DMU):

$$h_j = \frac{\sum_{r=1}^{s} u_{rj} y_{rj}}{\sum_{i=1}^{m} v_{ij} x_{ij}} \quad (2)$$

where
Y_{it} is the bank efficiency variable of bank i at the time t,
X_{it} is the innovation variables of bank i at the time t,
Z_{it} is the control variables of bank i at the time t,
$\propto$ is the constant,
β is the coefficient of innovation variables,
γ is the coefficient of control variables,
μ_i is the bank effect to cover the specific heterogeneity,
δ_{it} is time-varying across banks and over time.

While other production functions require some assumptions for measuring efficiency value, the DEA does not need any requirements. There is no particular DEA model; all the weights of input and output are the same. However, the efficiency value may be high and bias if the measurement has large input variables; thus, the number of inputs must be limited to minimize the DEA method's risk (Contreras, 2020, Yu et al., 2021).

In the finance sector, the DEA is used for measuring the bank efficiency variable by various scholars, and the selection of inputs and outputs is a controversial issue (Fethi & Pasiouras, 2010). Henriques et al. (2018) used three components for input variables, which encompass fixed assets, total deposits, and personnel expenses for inputs, and output is total loans. Tamatam et al. (2019) determined that the inputs consist of total assets and total deposit, while outputs include interest income, total income, and operating profit. In this study, the bank efficiency variable (EFF) is computed by the inputs are labor and capital, and the output is revenue. The approach is like the pure DEA of Charnes et al. (1978) and Seiford and Zhu (1999). However, the unit of currency between Vietnam and Pakistan are different; hence we use the exchange rate of USD/VND (Vietnam) and USD/Rupees (Pakistan)

at the end of the year, which the MorningStar provides for converting the value of capital and revenue from VND and Rupees to USD.

Innovation variables

In the literature review paper of Anagnostopoulou (2008), the author stated that the intangible asset's value reflects R&D measure in the financial statements. It is the comprehensive measure when approaching R&D measurement in the term of accounting figure. Additionally, intangible assets are also the crucial component of innovation; thus, Flor and Oltra (2004) proposed using the intangible assets to measure the innovation variables. Besides that, Flor and Oltra (2004) and Lev (2000) agreed that the worth of patents, brand names, and other intangible assets is reflected in the financial statement's intangible fixed assets. Furthermore, we find that banks' financial statements in Vietnam and Pakistan meet the International Accounting Standard Requirements. Therefore, in this study, the innovation variables are computed using intangible assets (on the financial statement), namely the ratio of intangible assets on fixed assets (INR) and the growth rate of intangible assets (ING)

Control variables

In this study, control variables consist of bank age, bank size, and inflation, which are found in the study of Tamatam et al. (2019), Phan et al. (2016), Faruq and Yi (2010), and Kapelko and Lansink (2015).

- Bank age (AGE) is the number of years from the original launch to the time t.
- Bank size (SIZE) is the logarithm of bank total assets.
- Inflation (INF) is the consumer price index rate, followed by the World Bank definition.

Table 1. Statistical description

Var.	Observation			Mean			Standard Deviation			Minimum			Maximum		
	Sap.	VN	PK	Sap.	VN	PK	Sap.	VN	PK	Sap.	VN	PK	Sap.	VN	PK
EFF	207	63	144	0.37	0.14	0.47	0.24	0.05	0.22	0	0.06	0	0.99	0.30	0.99
INR	207	63	144	0.22	0.51	0.08	0.26	0.24	0.11	3e-3	0.02	3e-3	0.98	0.98	0.52
ING	207	63	144	0.67	0.28	0.83	3.41	0.93	4.04	-1.00	-1.00	-0.52	42.90	6.73	42.90
AGE	207	63	144	27.74	29.71	26.88	10.51	10.53	10.42	6	19	6	58	58	48
SIZE	207	63	144	17.59	12.61	19.77	3.42	0.69	0.98	11.17	11.17	17.26	21.84	14.03	21.84
INF	18	9	9	0.06	0.03	0.07	0.03	0.01	0.03	0.01	0.01	0.03	0.12	0.05	0.12

Note: Sap., VN, and PK means the sample of this study, Vietnam, and Pakistan, respectively

Source: The State Bank of Pakistan, The Vietstock, The Bank Website, and The World Bank

Furthermore, in this study, we also aim to investigate the difference in efficiency between banks in Vietnam and Pakistan; thus, the country's dummy variable is considered. The country variable (COU) is 1 (one) if the bank is in Vietnam and is 0 (zero) if the bank is in Pakistan.

Data collection

In this study, we toward to use the nonprobability sampling technique for data collection. Although this technique has some limitations compared to the probability sampling technique, it is useful in investigating specific firm-level data of the socio-economic field (Etikan et al., 2016). We argue that this technique is suitable for research because of two reasons. Firstly, we strategy to set up the balanced panel; thus, the bank annual financial statement must be available during the scope of time. If the financial statement and/or annual report of any year are not available, the bank will be dropped out. Secondly, we toward to collect the data from the listed banks because the financial statement of the listed bank is audited, and the data of listed banks are more trusted than that of unlisted banks. Furthermore, we found the common point between Vietnam and Pakistan's banking industries that from 2011, both countries' banking industry seemed to escapes the global financial crisis 2008-2009 (Vo, 2016, Vidyakala et al., 2011). Thus, we choose the time of scope from 2011 to 2019 (present) to collect data.

Table 2. Correlation matrix and VIF.

Variable	VIF	EFF	AGE	SIZE	INF	INR	ING
EFF	-	1.000					
AGE	1.06	-0.323	1.000				
SIZE	2.90	0.630	0.038	1.000			
INF	1.50	0.450	-0.154	0.538	1.000		
INR	2.68	-0.515	-0.076	-0.787	-0.473	1.000	
ING	1.02	-0.069	0.033	0.082	0.108	-0.048	1.000

Source: Authors' own.

The data from seven banks in Vietnam and sixteen banks in Pakistan from 2011 to 2019 are set up. The audited financial statements are provided by the Vietstock and the State Bank of Pakistan, which revealed intangible assets, total assets, and revenue. The banks' website provides the annual report where the number of employees and bank age is collected. Moreover, inflation is collected from the World Bank website, and the MorningStar provides the currency exchange rate.

Table 3. The estimation results of the Pooled, FE and RE.

Variable	Pooled	FE	RE	Pooled	FE	RE	Pooled	FE	RE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
CONS.	-0.945***	-2.924***	-1.789***	-0.907***	-3.051***	-1.788***	-0.890***	-2.973***	-1.487***
	[-3.12]	[-3.68]	[-3.94]	[-3.01]	[-3.83]	[-3.94]	[-3.11]	[-3.74]	[-3.65]
AGE	-0.010***	-0.015*	-0.010***	-0.010***	-0.017*	-0.010***	-0.016***	-0.020**	-0.015***
	[-7.03]	[-1.67]	[-4.22]	[-7.22]	[-1.89]	[-4.22]	[-8.84]	[-2.20]	[-5.74]
SIZE	0.082***	0.206***	0.125***	0.081***	0.215***	0.125***	0.088***	0.214***	0.116***
	[5.11]	[3.62]	[5.07]	[5.10]	[3.79]	[5.10]	[5.81]	[3.79]	[5.32]
INF	0.868**	1.467**	1.112***	0.924**	1.528***	1.183***	0.930**	1.5-2***	1.108***
	[2.00]	[3.74]	[2.91]	[2.15]	[3.92]	[3.11]	[2.28]	[3.85]	[2.93]
COU	0.320**	omitted	0.640***	0.354***	omitted	0.641***	0.311***	omitted	0.496***
	[2.58]		[3.35]	[2.87]		[3.32]	[2.65]		[2.87]
INR				-0.102	0.104	-0.005	-0.774***	-0.205	-0.575***
				[-1.41]	[0.68]	[-0.05]	[-4.98]	[-0.77]	[-2.84]
ING				-0.008**	-0.007**	-0.007**	-0.008**	-0.007**	-0.007**
				[-2.49]	[-2.28]	[2.43]	[-2.51]	[-2.24]	[-2.38]
INR*AGE							0.031***	0.017	0.027***
							[4.82]	[1.41]	[3.07]
Obs.	207	207	207	207	207	207	207	207	207
R-Square	0.5366	0.1381	0.1290	0.5554	0.1634	0.1465	0.6018	0.1727	0.1382
Val.	58.48***	9.67***	82.51***	41.64***	6.99***	89.48***	42.96***	6.19***	125.52***
Haus.	-	10.52**		-	11.42**		-	13.69**	
Wal. /Bre.	-	1956.75***	-	-	2530.87***	-	-	1555.11***	-
Woo.	-	0.129	-	-	0.288	-	-	0.269	-

Variable	Pooled	FE	RE	Pooled	FE	RE	Pooled	FE	RE
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
CONS.	-0.888***	-3.302**	-1.785***	-0.950***	-2.963***	-1.828***	-0.943***	-3.002***	-1.851***
	[-2.89]	[-3.81]	[-3.71]	[-3.15]	[-3.72]	[-3.99]	[-3.09]	[-3.76]	[-4.03]
AGE	-0.010***	-0.018**	-0.010***	-0.010***	-0.016*	-0.010***	-0.010***	-0.016*	-0.010***
	[-7.04]	[-1.97]	[-4.06]	[-6.97]	[-1.79]	[-4.02]	[-7.17]	[-1.76]	[-4.09]
SIZE	0.080***	0.230***	0.124***	0.082***	0.209***	0.126***	0.082***	0.210***	0.128***
	[4.88]	[3.81]	[4.75]	[5.19]	[3.68]	[5.09]	[5.16]	[3.70]	[5.14]
INF	0.930**	1.548***	1.195***	1.038**	1.597***	1.293***	0.951**	1.550***	1.220***
	[2.16]	[3.95]	[3.14]	[2.39]	[4.07]	[3.38]	[2.21]	[3.96]	[3.20]
COU	0.354***	omitted	0.650***	0.369***	omitted	0.661***	0.360***	omitted	0.657***
	[2.86]		[3.29]	[2.99]		[3.37]	[2.91]		[3.34]
INR	-0.194	0.595	-0.124	-0.101	0.069	-0.018	-0.093	0.096	0.001
	[-0.67]	[0.87]	[-0.28]	[-1.40]	[0.44]	[-0.16]	[-1.28]	[0.62]	[0.01]
ING	-0.008**	-0.007**	-0.007**	0.010	0.009	0.011	0.032	0.030	0.036
	[-2.50]	[-2.22]	[-2.44]	[0.84]	[0.78]	[1.02]	[0.67]	[0.73]	[0.86]
INR*SIZE	0.007	-0.031	0.008						
	[0.33]	[-0.74]	[0.29]						
ING*AGE				-0.001	-4.4e-3	-0.001*			
				[-1.56]	[-1.43]	[-1.73]			
ING*SIZE							-0.002	-0.002	-0.002
							[-0.85]	[-0.89]	[-1.04]
Obs.	207	207	207	207	207	207	207	207	207
R-Square	0.5556	0.1660	0.1467	0.5608	0.1729	0.1574	0.5570	0.1671	0.1515
Val.	35.54***	5.90**	86.32***	36.30***	6.20***	90.10***	35.74***	5.95***	87.80***
Haus.		11.55*			8.49			10.02	
Wal. /Bre.	-	6235.13***	-	-	-	44.11***	-	-	42.88***
Woo.	-	0.241	-	-	-	0.403	-	-	0.386

*Note: *, **, and *** are the significant level at 10%, 5% and 1%, respectively.*
Haus., Wal. /Bre., and Woo. are Hausman test, Wald test/ Breusch, and Pagan Lagrangian test, and Wooldridge test, respectively.

Source: Authors' own.

The descriptive statistics of all variables can be seen in Table 1. Most variables have 207 observations for 23 banks in 9 years, except the INF variable has 9 observations in Vietnam and 9 observations in Pakistan, representing a yearly and repeated macroeconomic condition for each bank in each country. The mean of EFF is 0.37, 0.14, and 0.47 for the sample, Vietnam, and Pakistan, respectively; it reveals that banks in Vietnam are less efficient than in Pakistan. However, we find the inefficiency bank is in Pakistan (the minimum of EFF in Pakistan is 0). INR's mean indicates that the ratio of intangible assets on fixed assets in Vietnam is higher than in Pakistan; namely, INR's mean is 0.51 and 0.08 for Vietnam and Pakistan, respectively. However, Pakistan's intangible fixed assets' growth rate is higher than in Vietnam (the mean of ING is 0.81 and 0.28 for Pakistan and Vietnam, respectively). Based on the descriptive statistics of EFF, INR, and ING, it seems the using intangible fixed assets of the bank in Pakistan is more efficient than in Vietnam. Additionally, the mean of AGE in Vietnam is older than in Pakistan, but the mean of SIZE in Vietnam is smaller than in Pakistan. The average of INF in Vietnam is lower than in Pakistan.

Results

Table 2. gives that there is no evidence of multicollinearity. All variables are eligible for the regression analysis model because the maximum absolute values of correlation coefficients between variables are 0.787, less than 0.8 (Gujarati & Porter, 2009). The variance inflation factor (VIF) value of variables is very low (VIFmax = 2.90 < 4.00),

which is under the threshold of the VIF of the model having less than ten explanatory variables (Salmerón Gómez et al., 2020).

For investigating the effect of innovation on banks' efficiency in Vietnam and banks in Pakistan, equation (1) is modified and estimated as these steps. Firstly, we estimate the effect of bank age, bank size, inflation, and country variables on bank efficiency. Secondly, innovation variables are added. Finally, the interaction between bank characteristics and innovation is also considered.

Table 3 shows the estimation of all modified models processed by the Pooled, FE, and RE approach. All estimation result models are significant level at 1%. Because the COU is the dummy variable, it is omitted when processed by the FE approach, but it does not influence the Hausman test's estimation results. The Hausman test's value shows that if it is significant at a level to lower 10%, the FE estimation is better than that of the RE. In the case of this study, there are four estimation results of the FE that are more suitable than of the RE (see column 2-5-8-11), and two of the RE are more appropriate than of the FE (see column 15-18). The Pooled estimation results reveal that the models' independent variables explain 53.66% to 60.18% of bank efficiency change.

Table 4. The estimation of the Generalized Least Square model.

Variable	(19)	(20)	(21)	(22)	(23)	(24)
CONS.	-0.754***	-0.673***	-0.532**	-0.594***	-0.757***	-0.735***
	[-3.97]	[-3.76]	[-2.41]	[-2.79]	[-4.20]	[-3.95]
AGE	-0.007***	-0.008***	-0.011***	-0.007***	-0.007***	-0.008***
	[-7.65]	[-7.84]	[-8.08]	[-7.32]	[-7.36]	[-7.86]
SIZE	0.070***	0.066***	0.064***	0.061***	0.069***	0.069***
	[6.94]	[7.09]	[5.50]	[5.32]	[7.33]	[7.12]
INF	0.609*	0.540*	0.821**	0.620**	0.760**	0.586**
	[1.93]	[1.80]	[2.30]	[2.05]	[2.55]	[1.96]
COU	0.214***	0.211***	0.182**	0.186**	0.243***	0.231***
	[2.78]	[2.89]	[2.08]	[2.26]	[3.30]	[3.08]
INR		-0.061***	-0.502***	-0.197	-0.059***	-0.055***
		[-3.20]	[-5.35]	[-1.34]	[-3.11]	[-2.71]
ING		-0.007***	0.009***	-0.007***	0.007	0.012
		[-3.19]	[-3.60]	[-3.25]	[1.35]	[0.68]
INR*AGE			0.018***			
			[4.70]			
INR*SIZE				0.011		
				[0.93]		
ING*AGE					-4.7e-3***	
					[-2.76]	
ING*SIZE						-0.001
						[-1.06]
Obs.	207	207	207	207	207	207
Val.	707.89***	827.05***	609.66***	842.10***	903.30***	847.54***

*Note: *, **, and *** are the significant level at 10%, 5% and 1%, respectively*

Source: Authors' own

In contrast, the FE and RE explanation percentage is low, which fluctuates around 15%. All coefficients of AGE, SIZE, INF, and COU are significant at 1% to 10% (most of them are 1%). While coefficients of AGE are negative, coefficients of SIZE, INF, and COU are positive. Column 7 and column 9 show that INR's coefficients are significant negative level at 1%, and the coefficients of INR*AGE are significant positive level at 1%. Column 4 to column 13 also indicate the significantly negative ING coefficients are at 1%-10% interval. ING*AGE's coefficients are a significant positive level at 10% (see column 15).

Based on the Hausman test's value (see Haus. row in Table 3), the heteroskedasticity and the autocorrelation (namely columns 2, 5, 8, 11, 15, and 18) are estimated by the Wooldridge test, and Wald test/Breusch and Lagrangian test. The Wooldridge test (see Woo. row) gives no autocorrelation. The Wald test/Breusch and Lagrangian test (see Wal. /Bre. row) revealed a heteroskedasticity issue at 1% significant.

For fixing the heteroskedasticity issue, we apply the GLS approach for estimating the effect of independent variables on the dependent variables; the estimation results by the GLS are shown in Table 4. The results show that all models are significant at 1%, and the significant sign of independent variable coefficients is like the estimation results of Table 3.

Robustness check

The value of bank efficiency is from zero (0) to one (1), hence in this sub-section, we use the Tobit approach for robustness to check the estimation result. The estimation of the Tobit approach can be seen in Table 5. All estimation results of models by the Tobit approach are at a significant level at 1%. All coefficients of AGE, SIZE, INF, and COU variables are significant and have a sign like the estimation in Table 3.

Table 5. The estimation of the Tobit model.

Variable	(25)	(26)	(27)	(28)	(29)	(30)
CONS.	-0.945***	-0.907***	-0.890***	-0.888***	-0.950***	-0.943***
	[-3.16]	[-3.06]	[-3.17]	[-2.95]	[-3.21]	[-3.15]
AGE	-0.010***	-0.010***	-0.016***	-0.010***	-0.010***	-0.010***
	[-7.12]	[-7.35]	[-9.01]	[-7.18]	[-7.11]	[-7.31]
SIZE	0.082***	0.081***	0.088***	0.080***	0.082***	0.082***
	[5.17]	[5.18]	[5.93]	[4.97]	[5.29]	[5.26]
INF	0.868***	0.924**	0.930**	0.930**	1.038**	0.951***
	[2.03]	[2.19]	[2.33]	[2.20]	[2.44]	[2.25]
COU	0.320***	0.354***	0.311***	0.354***	0.369***	0.360***
	[2.61]	[2.92]	[2.70]	[2.92]	[3.05]	[2.97]
INR		-0.102	-0.774***	-0.194	-0.101	-0.093
		[-1.43]	[-5.08]	[-0.68]	[-1.43]	[-1.31]
ING		-0.008**	-0.008**	-0.008**	0.010	0.032
		[-2.53]	[-2.56]	[-2.55]	[0.85]	[0.69]
INR*AGE			0.031***			
			[4.91]			
INR*SIZE				0.007		
				[0.33]		
ING*AGE					-0.001	
					[-1.59]	
ING*SIZE						-0.002
						[-0.87]
Obs.	207	207	207	207	207	207
Val.	159.22***	167.78***	190.61***	167.89***	170.31***	168.53***

*Note: *, **, and *** are the significant level at 10%, 5% and 1%, respectively*

Source: Authors' own.

INR's coefficient (see column 27) shows the significant negative link between bank efficiency and the ratio of intangible assets on fixed assets at a level of 1%. The same estimation results of the growth rate of intangible assets on bank efficiency, the coefficients of ING are significantly negative at 5% (see column 26-27-28). Additionally, the INR*AGE coefficient is significantly positive (see column 27). Other variables of the interaction between innovation and bank characteristics do not associate with bank efficiency.

The Pooled, FE, RE, GLS, and Tobit approach's estimation results differ in Vietnamese banks and Pakistani banks' efficiency. Moreover, we aim to robust the difference in bank efficiency between two countries with and without the innovation effect. The Pooled and Tobit approach's estimation results do not reflect the difference in the panel data's time-series and cross-section components. In contrast, the estimation results of the FE and RE have the heteroskedasticity issue; thus, estimating the expectation value of bank efficiency by the influence of innovation, we use the estimation results by the GLS approach. Based on Table 4, five equations of the bank efficiency expectation are chosen and shown in the "note" of Table 6. The T-test approach's estimation result provides that the banks in Pakistan are more efficient than in Vietnam in both cases of with and without innovation. Moreover, the efficiency under innovation's effect is smaller than the efficiency without innovation, excluding Vietnam's case (see column d). Under the effect of innovation, Vietnam's bank efficiency is improved (0.163 compared to 0.143).

Table 6. Comparison of bank efficiency between Vietnam and Pakistan.

Group	Obs.	Mean of bank efficiency					
		(a)	(b)	(c)	(d)	(e)	(f)
Pakistan	144	0.473	0.462	0.469	0.460	0.452	0.467
Vietnam	63	0.143	0.131	0.135	0.163	0.131	0.130
Combine	207	0.372	0.362	0.367	0.370	0.354	0.364
Difference		0.330	0.332	0.334	0.297	0.321	0.337
t-value		12.027***	31.705***	27.847***	28.927***	24.526***	33.621***
Pro. (PK ≠ VN)		0.000	0.000	0.000	0.000	0.000	0.000
Pro. (PK > VN)		0.000	0.000	0.000	0.000	0.000	0.000
Pro. (PK < VN)		1.000	1.000	1.000	1.000	1.000	1.000

*Note: *, **, and *** are the significant level at 10%, 5% and 1%, respectively.*
(a) indicates bank efficiency is calculated by the equation (2)
(b), (c), (d), (e), and (f) indicate bank efficiency affected by innovation, which calculated by the significant estimation results of GLS, namely the results of column (20), (21), (22), (23), and (24) in table 4, respectively.

Source: Authors' own.

Discussion

Like most previous studies, the estimation results show that in the banks in Vietnam and Pakistan, the large bank is more efficient than the small bank (Phan et al., 2016, Faruq & Yi, 2010). Vietnam and Pakistan are emerging

countries. The rate of people using banking products is low (Demirgüç-Kunt et al., 2018); thus, we discuss that the bank with more considerable assets is easy to access the niche market and optimize efficiency by scale up the size. However, the older bank is less efficient than the young bank (Cheruiyot, 2017). After reviewing the bank in the study sample and looking for the owner structure, we found that the state controls most older banks. Burki and Niazi (2010) and Bonin et al. (2005) gave that state-owned banks performed poorly efficiently when comparing with other kinds of banks (foreign and private banks). Additionally, the regulation of limited the number of bank branches in the regions (city, province, or town) makes the older banks extend their network to the rural areas, where having higher operation cost (Burki & Niazi, 2010). We discuss one reason for explaining that the older bank is less than efficient than the young bank.

In this study sample, the mean of inflation is 5.6%, and the influence of inflation on bank efficiency is significantly positive. When the rate of consumer price index increases, the bank efficiency is higher, we argue that this is suitable for developing countries like Vietnam and Pakistan. The proper inflation will increase bank efficiency and grow the economy.

The difference from the previous studies by Tamatam et al. (2019), Frei et al. (1997), and Wang et al. (2020), in this study, there is proof of a negative association between bank efficiency and innovation. The growth rate of intangible assets decreases bank efficiency, whereas the relationship between intangible assets' ratio on fixed assets and bank efficiency is inexplicit. As we mentioned in the literature review section, under the pressure of competitiveness, increasing innovation in the banking sector is mandatory to enhance bank efficiency. However, in this study sample, the bank's innovation activities in Vietnam and Pakistan are not sufficient, and bank efficiency does not increase. We argue that the reasons might be from bank ownership characteristics (Tamatam et al., 2019) or market concentration (Phan et al., 2016), which are not considered in this study's research model. Additionally, because of the low rate of banking users on population in Vietnam and Pakistan (Demirgüç-Kunt et al., 2018, Demirgüç-Kunt & Klapper, 2013), the bank can increase the income without the concentration of innovation. Besides that, the banks in developing countries get more benefit from the support of the monetary policy. Chen et al. (2017) gave that in developing countries, the bank profitability has positive with the easy monetary policy. In Vietnam and Pakistan, the monetary policy facilitates increasing bank profit (Nguyen et al., 2017, Janjua et al., 2014).

Moreover, we discuss that the negative effect of innovation on bank efficiency in Vietnam and Pakistan might come from the bank's human capital, which is not considered in this study. Khan et al. (2020) found that human capital and innovation have a positive with financial development. In the case of Vietnam and Pakistan, the bank's human capital does not meet the requirement of innovation in the banking sector. Moreover, there is the effect of the interaction of innovation and bank age on bank efficiency. However, there is no proof of the effect of innovation and bank size on bank efficiency. We discuss that the young banks focus on more applying innovation to enhance bank efficiency than the older banks.

The moderating of bank size on the link between efficiency and innovation is not significant. We argue age is the main reason for bank slowness in innovation, which has created a new form of companies, the fintech start-up company. The fintech company is very young that is applying innovation for providing financial products to the customers is a threat to the banking industry (Klus et al., 2019).

Furthermore, there is a difference in efficiency between banks in Vietnam and banks in Pakistan, namely the Pakistani bank is more efficient than the Vietnamese bank. It is consistent with the results study by Tamatam et al. (2019), Pasiouras et al. (2009), Du and Sim (2016), and Nguyen (2018), which indicated the effect of location on efficiency. Additionally, this result is suitable for the discussion on the literature review. However, we explore that this result is not holistic because it does not explain the different features. Pérez-Nordtvedt et al. (2008) used the cross-culture variable for investigating the efficiency of international businesses. Thus, we believe that cross-culture will be the more in-depth variable of the cross-country variable, explaining the apparent difference in efficiency between cross-border banks. Pakistan is an Islamic nation, while Vietnam is a multi-religion; thus, we argue that Islamic regulation is the factor of the difference in efficiency between banks in Pakistan and banks in Vietnam. Alqahtani et al. (2017) indicated that Islamic banks are more efficient than conventional banks.

Conclusion

In this study, we aim to investigate the effect of innovation on bank efficiency in emerging countries, namely the Vietnam and Pakistan transition economy, which strongly link to innovation. According to the financial sector data of the World Bank, we could not determine the difference in bank efficiency between the two countries; thus, we strategy to investigate the difference in the efficiency of the Vietnamese and Pakistani banks under the effect of innovation. We aggregated the balanced panel data from various trusted sources, namely The State Bank of Pakistan, The Vietstock, The Bank Website, the MorningStar, and The World Bank. The dataset from 7 banks in Vietnam and 16 banks in Pakistan in 2011-2019 was collected to estimate the effect of innovation on two countries' bank efficiency. The Pooled, FE, RE, and GLS approaches are applied to estimating the quantitative research models of bank efficiency, innovation, bank characteristics, and macroeconomic condition. The estimation results are validated again by the Tobit approach and the T-test method. The outcomes give that the relationship between

bank efficiency and innovation is negative. In contrast, bank age is the negative factor of bank efficiency; bank size and inflation are the positive factors. Additionally, we explore that the efficiency of banks in Pakistan is higher than in Vietnam.

Based on the research outcomes, we find that although innovation plays a crucial role in the transition economy, it is a negative factor in Vietnam and Pakistan's banking industry. The bank can penetrate the market gap for increasing profit instead of innovative investment for enhancing efficiency. The bank can increase the size by increasing the number of branches to enhance bank efficiency. Although the banks in Vietnam are less efficient with and without the effect of innovation than in Pakistan, we explore that the banks in Vietnam are more easily increased efficiency than in Pakistan. Additionally, the slowness by the age of banks in innovation is negative for enhancing bank efficiency, creating opportunities for the fintech companies. Furthermore, we find that the macroeconomic condition has been supporting bank efficiency in both countries.

A negative relationship between bank efficiency and innovation in the transition economies and the difference in efficiency between the bank in Vietnam and Pakistan are interesting findings. We consider that which are the main contributions of the study. Besides that, utilizing the pure DEA for measuring efficiency in the banking industry is also a significant contribution. However, we consider that the study also has some limitations. Firstly, as we mentioned above, besides bank characteristics and macroeconomic conditions, the effect of innovation on bank efficiency is controlled by other factors such as human capital, bank innovation strategy, and even monetary policy. We suggest that the next research might consider these factors for investigation. Secondly, the bank efficiency might be measured by other approaches (e.g., Stochastic Frontier, Fuzzy DEA), and the choice of inputs and outputs components might be different. Thus, we suggest that these approaches might be considered for the next research.

Besides, we suggest that the findings might be meaningful for bank managers and policymakers. The bank can extend the number of branches (increasing physical assets) to enhance bank efficiency instead of increase R&D activities. However, the bank needs to be proactive for adaptation to the fintech company's rise, optimizing advanced technology in the banking industry. Besides that, as discussed above, practicing the strict rule of Muslims increases bank efficiency. Thus, we propose that the bank in Vietnam consider the regulation of banks in Pakistan for implementation.

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