The effect of merger to Vietnamese bank efficiency: A two-step DEA window analysis approach

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Abstract:

The study examines the role of mergers and acquisitions (M&As) on bank efficiency over the 2008-2016 period, using a balanced panel dataset from 22 commercial banks in Vietnam. The study employs the two-stage DEA window analysis approach. In the first stage, the DEA window analysis is used to estimate the technical efficiency of the Vietnamese banks. In the second stage, the efficiency is regressed on the merger dummy and other control variables using tobit, truncated and bootstrap methods as robustness checks. Our findings suggest that, first, the efficiency of Vietnamese banks decreases after M&As. There are two possible explanations for this finding: first, the M&As are not driven by profit-maximizing incentives; second, it may due to the intervention by the government to rescue weak banks. In addition, the newly-formed entities need to spend additional resources on resolving the bad debts transferred from the weak, targeted banks. The results are robust in all specifications employing tobit, truncated, and bootstrap methods.

JEL classifications: G21; G32; G34.

Keywords. *Banking; M&A; Efficiency*

1. Introduction

Mergers and acquisitions (M&As) are common economic phenomena through which firms acquire another firm's assets (Ferraz & Hamaguchi, 2002). Great attention has been devoted to investigating the economic impacts of M&As in the banking sectors in developed countries such as the U.S and European countries (DeYoung, Evanoff, & Molyneux, 2009). This is because, in any economy, the banking sector is the backbone supporting economic growth. M&As, on the other hand, attracts public attention, because M&As could lead to higher market power, allowing banks to set a higher price, which in turn, have a negative impact on social welfare (Ferraz & Hamaguchi, 2002). It is also important for policymakers to understand the impact of M&As so that they can design policies to navigate the financial markets. Banks, in general, are concerned whether a potential M&A could create value to their existing shareholders, either in the long-term or short-term. However, the majority of studies on the effects of M&As in the banking sectors are conducted in developed countries such as in the US and European countries in the 1980s-90s (DeYoung et al., 2009). Studies of M&As in developed countries focus on the profit-driven motive behind a M&A, whether to gain long-term profit by improving operating efficiency, increase market power or earning short-term abnormal M&A induced returns in the stock markets. Nevertheless, Dymski (2002) argues that both macrostructural circumstances (e.g. regulatory regimes, or macroeconomic conditions[1]) and banks' strategic motives are important attributes leading to the various M&A waves in world history. Owing to these differences among countries, the efficiency-driven pattern applied in developed countries might not reflect the situation in developing countries. The mixed results on the impact of M&As in different institutional settings confirm this argument.

In this study, we investigated the effect of M&As on bank performance in Vietnam, a developing country. We tested whether there was efficiency improvement after some recent M&A events, as predicted under the U.S setting. It was worthwhile to conduct the study because the motives for the M&As in Vietnam are different from those we witnessed in both developed and developing countries in the past. In the U.S, the M&A waves, which happened in the 80s-90s, were associated with the expansion of businesses of outstanding individual banks which took over failed or near failed banks to increase their market shares. South-East Asian countries, on the other hand, experienced the M&A waves after the burst of the 1997 financial crisis. The main types of M&As were cross-border, from which the government encouraged foreign investors from developed countries to purchase assets of local distressed

[1] such as the business environment of banking firms, the pace of economic growth, the size and mature level of the domestic market.

banks. As a result, acquirers from developed countries found M&As as opportunities to increase their presence in the high-growth local markets. Unlike the case of the U.S, the recent wave of M&A in Vietnam comes from the strategy initiated by the government to restructure the banking sector. Unlike in South-East Asian countries, the Vietnamese government is more conservative in opening the banking system to foreigners[2]. Therefore, the M&As in Vietnam are between domestic banks. In fact, the M&As in the Vietnamese banking sectors are not purely driven by market forces, but also by government enforcement. In contrast, Vietnam is a relevant research topic because of its large population and a good record of economic growth. The Vietnamese banking industry also has great potential for development given the large population and low level of financial inclusion. Therefore, foreign investors who seek a high-growth market in which to invest will find it valuable to understand the development in the banking sector in Vietnam.

The study employs the two-stage DEA window analyses approach to scrutinize the impact of M&As on the Vietnamese bank technical efficiencies. In the first stage, the DEA window analysis is used to estimate the technical efficiency of Vietnamese banks. In the second stage, the efficiency is regressed on merger dummy and other control variables using tobit, truncated and bootstrap methods as robustness checks. Data envelopment analysis (DEA), together with stochastic frontier analysis (SFA), are among frontier analysis methods that are widely employed in assessing bank efficiency (Berger & Humphrey, 1997; Fethi & Pasiouras, 2010). SFA, first introduced by Aigner, Lovell, and Schmidt (1977), is a parametric approach, while DEA, proposed by Charnes, Cooper, and Rhodes (1978), and is a non-parametric technique. Both analyses are based on measuring the distance from the production functions' frontier to measure inefficiency. There is no consensus on whether DEA or SFA is better because both have merits and demerits; rather, the choice of method depends on the purpose of the empirical work. Since DEA provides information on the peer group, while SFA does not (Nguyen, Roca, & Sharma, 2014), DEA is an appropriate approach for this study because we have a small sample and want to detect performance trends for specific banks over time (Asmild, Paradi, Aggarwall, & Schaffnit, 2004). In addition, we also incorporate the DEA with the window analysis technique, which groups data on banks in three years into a three – year "window" and treats them as if they represent different firms. This method mitigates the effect of outliers because the ultimate efficiency scores are the average mean of efficiencies of three consequent years. Likewise, it also partly

[2] Foreign entities can hold up to 20% of a local bank's assets. Even though the government, in principle, encourages foreign banks to buy up 100% assets of a weak bank, the limitation in regulatory framework prevents it happening in reality.

incorporates the effect of technological changes over time. The DEA window analysis, therefore, is regarded as the sensitivity method and facilitates the use of the bootstrap technique. Details of the methodology are elaborated on in the Methodology section.

The rest of the paper is organized as follows: Section 2 provides the M&As in Vietnam. Section 3 provides the hypothesis development based on prior research on the impact of M&As on bank efficiency; Sections 4 describes the methodology and data; Sections 5 reports the efficiency scores and the main hypothesis testing; Sections 6 provides the conclusion and suggestions for future research.

2. The Vietnamese banking sector and M&As

Before 2008, the Vietnam government had been conducting the expansionary monetary policy in the 2002-2007 period (with an average of nearly 30% YoY growth rate). The abundance of money in the economy, for a long time, led to the high inflation and bubble in the real estate market. Consequently, the inflation rate rose markedly, from 8.3% in 2007 to 23.12% in 2008. At the same time, the global financial crisis caused a sharp slowdown in Vietnamese exports, due to the decrease in demands for Vietnamese goods from the major importing countries. As a result, the macroeconomic conditions in Vietnam deteriorated quickly with increasing dollarization, the frozen real estate market, a sharp decline of the stock market, and a rapid increase in non-performing loans. In the 2008-2011 period, while M2 growth rate on average was 26.56%, non-performing loans (NLPs) were estimated to grow at 51% YoY.

Hence, the government issued Decision 254/QD-TTg dated March 01, 2012 on approving the Scheme on "Restructuring the credit institution system in the 2011-2015" to restructure the banking system. According to Decision 254, one of the aims of the restructuring program aims at: improving the operational efficiency and safety of local banks; enhancing market discipline in banking activities; and diversifying structure of types, ownership, sizes of the banking system to be more consistent with international standards. To achieve the goals, the State Bank of Vietnam focuses on delivering three tools: first, resolving bad debts in the system; second, encouraging (in some cases, forcing) bank mergers and acquisitions; and third, encouraging foreign banks to cooperate with domestic banks to help improve governance and risk management of the local banks. The State bank also conducted allocating credit growth limits to each bank based on their previous performance to curve credit growth.

M&As in Vietnam have been occurring, particularly since 2012, with two M&As in 2012, one in 2013, and three in 2015. However, unlike what had happened in the U.S with profit-induced M&As or some other Southeast Asian countries with cross-border M&As, the

M&As in Vietnam were among the efforts by the government to clean up the fragmented financial markets and prevent the possible collapse of the banking system if letting weak banks fail. Therefore, the M&As in Vietnam more or less have the involvement of the government. On the one hand, the government encouraged weak banks to find a healthier bank to merge with. Otherwise, the government would intervine in the operations of the weak banks. As a result, private banks which shared the same major shareholders, were encouraged to merge. For example, MB acquired MDB bank because MB is one of MDB's big shareholders (owned 10% the shareholding as of 2015). Saccombank acquired Southern bank for the same reason. Saigon bank was merged with Ficombank and Trust Bank because the three of them are owned by the same group of investors. On the other hand, the government has influenced state-owned enterprises/banks to merge with weak banks. For instance, Saigon-Hanoi Bank agreed to acquire Habubank as two big shareholders in Saigon-Hanoi bank are two state-owned enterprises. BIDV were merged with MHB because they are both state-owned banks. In return, the government created favourable ? what? for the combined entities to conduct businesses. For instance, the State bank allocates the combined bank with a higher credit growth limit for those involved in restructuring weak banks, as well as supporting those banks to disclose collaterals.

On the other hand, the banking sector in Vietnam is characterised with the dominance of the state-owned banks in terms of lending, deposits and total assets. The four SOBs alone accounted for 47.1% of the total banking assets as at 2015. In terms of market shares, as at 2015, the SOBs account for 48.5% of total deposits and 54% of total loans to customers, although the shares have been decreasing over time. Meanwhile, private commercial banks[3] have rapidly increased their market shares, from 15% in 2005 to 37.8% in 2015 of total lending shares, and from 16% in 2005 to 41.6% in 2015 of the total deposit shares. Nevertheless, private banks have to compete severely with each other and with foreign banks to attract customers. In contrast, according to the World Bank, access to financial services in Vietnam is relatively low given the large population (nearly 100 million as of 2016), owing to the low number of bank branches, at 4 per 100,000 adults and ATMs, at 24 per 100,000 adults. A higher access to a formal financial system, could potentially boost economic growth and productivity over the long term (Demirguc-Kunt, Klapper, & Singer, 2017). Thus, the Vietnamese banking industry has great potential to increase revenue just by increasing the level of financial inclusion. Indeed, 90% of the income of Vietnamese banks comes from lending activities.

[3] Includes 28 commercial banks, 5 foreign banks, and 3 joint-ventured banks. There were 3 more foreign banks established in 2016.

To sum up, as the motives of the acquisition of weak banks were not led by a profit-maximizing decision, it is reasonable to expect deterioration in efficiency after M&As. However, we would expect an increase in lending and deposit quantities after M&As, because banks in Vietnam usually look to broaden the customer base and increase market share, given the strong competition and reliance on traditional services (i.e. lending) to generate income by Vietnamese domestic banks.

3. Research on value creation following banking M&As and hypothesis development

There are two strands of literature investigating the benefits of M&As. One strand uses financial ratios of performance (such as return on equity, return on assets) or productive efficiency (i.e. using frontier analysis approach) to measure possible merger-induced improvements. The other strand uses 'event-study' methodology to measure how the bond or stock markets react to a M&A announcement (DeYoung et al., 2009). Nevertheless, financial ratios are usually considered as a misleading indicator of performance because, first, they may be subject to manipulation by management[4], or off-balance sheet activities (Athanasoglou, Brissimis, & Delis, 2008; Trujillo-Ponce, 2013); second, they do not control for product mix or input prices or fail to represent economic value-maximizing behaviours by firms (Berger, Hunter, & Timme, 1993; Kohers, Huang, & Kohers, 2000). The event-study type methodology, on the other hand, can track whether there is an abnormal return (i.e. a rapid adjustment of the stock prices associated with the merger) following a M&A announcement (Asimakopoulos & Athanasoglou, 2013). In particular, these studies investigate whether the announcement of a bank merger creates value to the shareholders of the targeted bank and/or the combined entity (Altunbaş & Marqués, 2008). The assumption underlying this methodology is the stock market follows the "market efficiency hypothesis", meaning the stock market prices will react immediately and fully to incorporate all available information (Asimakopoulos & Athanasoglou, 2013). However, there are some criticisms of using this method. First, it is not easy to detangle the value creation as the result of improved efficiency or larger market power (DeYoung et al., 2009). Second, the assumption of perfect price adjustment following, or around a M&A event, conflicts with the conception of the integration process in the combined entity (Bernad, Fuentelsaz, & Gómez, 2010). In addition, market-based data can be severely distorted if the financial market is illiquid and opaque (Chiaramonte, Croci, & Poli, 2015) and the data is limited to listed firms only. These limitations make the use of this approach for Vietnam difficult.

[4] For example, banks will increase the leverage ratio, which leads to the increase in risk, to report higher ROE ratio. Off-balance sheet activities incur the same risk as loans, but do not calculate as assets, thus they can distort the ROA ratio.

In this study, we use the frontier analysis to measure the bank efficiencies. This methodology has some advantages: first, none of the profitability ratios on their own provide an adequate indication of bank efficiency (Halkos & Salamouris, 2004); second, efficiency is likely to be a more reliable measure of firms' performance (Hardwick, Adams, & Zou, 2011); third, it is possible to detangle the effect of scale efficiency from technical efficiency. Bernad et al. (2010) argue that the complexities of the integration process in terms of strategic and organizational harmonization in the combined entity require a long run for the benefits of the M&A to be realized. Therefore, regardless of methods used, the performance effects of M&As should be evaluated in the long-term. Indeed, Knapp, Gart, and Chaudhry (2006), using ROA and ROE as indicators of bank profitability, found that there is a substantial profit gain up to five years post-merger before they reverse back to the mean profitability of the industry. Fortunately, efficiency indicators can capture the realization of cost reduction in the longer term.

Conventional wisdom on potential gains from banking mergers and acquisitions (M&As) is that M&As may allow banks to maximize value by achieving improvement in X-efficiency, (i.e. the ability of management in controlling costs and generating revenues), scale and scope efficiency, or increase in market power (i.e. allowing banks to set prices less favourable to customers to raise profits) (Avkiran, 1999; Berger, Demsetz, & Strahan, 1999; Berger & Humphrey, 1997; Berger et al., 1993; DeYoung, 1997; DeYoung et al., 2009; Houston, James, & Ryngaert, 2001). Researchers also agree on two ex-ante conditions for banks to benefit more from merging with another bank, which are (i) the acquiring bank is more efficient than the acquired bank; and (ii) both banks are located in the same local market (Berger et al., 1999; Berger & Humphrey, 1997). Mergers have the potential to reduce costs thanks to scale and scope (product mix) economies[5]. Nevertheless, the literature shows that the inefficiencies from scale and scope economies usually accounts for a small cost (Berger et al., 1993). In contrast, the transfer of management practices from X-efficient[6] banks to X-inefficient target banks seems to associate with larger cost savings and revenue enhancement (Berger & Humphrey, 1994; DeYoung, 1997; Houston et al., 2001).

In line with the results of M&As and bank efficiency studies, the existing literature in banking M&As and efficiency can be divided into two periods, pre-2000 and post-2000. The

[5] The cost savings from scale economy may be achieved from eliminating redundant managerial positions, closing overlapping bank branches, etc.; meanwhile, the scope economy may come from the cross-selling of banking services, i.e. providing services to former customers of the acquired bank (Asimakopoulos & Athanasoglou, 2013; Houston et al., 2001).

[6] In essence, X-efficiency and scale and scope economies are different. A bank is considered as cost X-efficient when it could produce a given bundle of outputs with minimum cost for the input prices it faces, while scale and scope economies are measured in terms of least-cost scale and mix of the product bundle, when assuming that the bank is cost/revenue X-efficient (Berger & Humphrey, 1994).

pre-2000 literature on earlier frontier analysis, mainly from the US studies, provides evidence that M&As result in no or modest improvement on cost X-efficiency, (Berger et al., 1999; Berger & Humphrey, 1994; Berger et al., 1993; DeYoung, 1997). In addition, only small banks appear to have potential scale economy, while large banks might be subject to scale diseconomy (Berger & Humphrey, 1997). Therefore, the authors argue that the small improvement of cost X-efficiency from these mergers are offset by the scale diseconomies created by merging banks (Berger & Humphrey, 1997). The same finding was found in Australia in the 1986-1995 period that mergers did not bring about operating efficiency[7] gains (Avkiran, 1999). Nevertheless, the pre-2000 studies find improvement in profit X-efficiency. For example, Fixler and Zieschang (1993) employ Tornqvist productivity indices which take account of both cost effects through their input index and revenue effects through their output index as a measurement of efficiency. They have found evidence that merging banks tend to be more productive than average and are able to maintain their productivity advantage in subsequent years after the merger (Fixler & Zieschang, 1993). Akhavein, Berger, and Humphrey (1997) investigate the effect of profit efficiency of bank megamergers and find a 16% point average increase in profit efficiency rank relative to other large banks. The different findings with respect to cost X-efficiency and profit X-efficiency are believed to be due to the net benefits from M&As, and were mostly found in revenue enhancements, rather than cost improvements (Akhavein et al., 1997; Avkiran, 1999; Berger et al., 1993; Fixler & Zieschang, 1993).

The post-2000 period provides more evidence of the productive efficiency gains from mergers, however, the evidence is mixed and these studies are mainly conducted in developed country contexts. DeYoung et al. (2009) provide a literature review of post-2000 studies on the effects of M&As on bank performance and conclude that there is evidence of (cost) efficiency improvement in European bank mergers. More recent studies include Rezitis (2008), Bernad et al. (2010), Halkos and Tzeremes (2013). Rezitis (2008) employs a one-stage stochastic frontier analysis to test the effect of acquisition activity on the efficiency of Greek banks in the 1993-2004 period. The result indicates that the technical efficiency of merged banks deteriorates in the post-merger period, while there is no technological improvement or economies of scale in the period after merging compared to the period before merging. Bernad et al. (2010) investigate the effect of M&As on the productivity of savings banks in the 1987-2004 period in Spain. Based on the Cobb-Douglas production function, in which labor and capital constitute the two main inputs, and total production (sum of loans,

[7] Avkiran (1999) defines the operating efficiency as the ratio of non-interest expense to operating income, also known as the cost to income ratio.

securities, and shares) is the single output, the effect of mergers on banks' output are estimated. They find that half of the saving banks experience an improvement in productivity after a merger or acquisition. Halkos and Tzeremes (2013) take a different approach to analysing the economy of scope benefits from mergers. Instead of evaluating bank scope efficiency before and after a real merger, they examine whether there exist scope economies in 45 potential M&As from 18 Greek banks during the 2007-2011 period. They find that in the short-run (i.e. 2011) there are substantial operating efficiency gains thanks to the (virtual) mergers between two cost-efficient Greek banks. However, during the whole period, there is evidence that the majority of newly merged banks fail to generate efficiency gains.

To sum up, there are two strands of literature in measuring benefits from M&As. One strand of literature explores 'event study' – how the stock market prices react to or around a merger announcement. However, there are arguments that it takes time for the benefits resulting from mergers to be realized, due to complicated integration processes in the newly combined entities. Therefore, the effects of M&As should be investigated in the long run. The other strand of literature employs accounting ratios or frontier-based efficiency as measures of bank performance, of which the efficiency is considered a superior indicator of performance than accounting ratios. The literature on the effect of M&As on bank efficiency consists of studies in developed countries such as the US, and European countries. Studies in the US suggest that there is evidence of revenue efficiency gains following a M&A. However, American banks benefit from very little to not at all from cost efficiency improvement, because the minor benefits are usually being offset by scale diseconomies. Studies in Europe, in contrast, provide mixed results on efficiency gains by merging banks in the post-merger period.

In terms of efficiency and M&A studies in the Vietnamese context, to the best of our knowledge, there are no studies so far, partly because the M&A is still a new economic phenomenon which has just happened since 2012. There are some studies about Vietnamese bank efficiencies using both DEA and SFA techniques such as Nguyen et al. (2014), Vu and Turnell (2010), and (Ngo & Tripe, 2017).

Hence, based on the literature review and the context of the Vietnamese banking system in the investigated period, we have the following hypothesis:

Bank merger has a negative impact on the merging bank's efficiency. In other words, the acquiring bank experiences lower efficiency after a M&A.

4. Methodology and data

In order to test whether or not banks improve efficiency after acquiring another bank, we adopted the two-stage DEA window analysis method. The first stage involves measuring

technical efficiency using the DEA window analysis technique. The second stage is to test the relationship between technical efficiency and merger events employing the bootstrap method. Tobit and truncated methods are reported, as well as robustness checks.

Following Coelli, Rao, O'Donnell, and Battese (2005), the input-oriented technical efficiency of any bank under variable returns to scale is generated by solving the below linear programming problem:

$$min_{\theta,\lambda}\theta,$$

$$\text{s.t} \quad -y_i + Y\lambda \geq 0, \quad (1)$$

$$\theta x_i - X\lambda \geq 0, \quad (2)$$

$$N1'\lambda \leq 1, \quad (3)$$

$$\lambda \geq 0$$

Where the equation (3) is to ensure the frontier is convex to account for the various returns to scale. θ is the technical efficiency and θ and λ are calculated by the linear programming, x_i is the cost-minimizing vector of input quantities for the i-th bank, given the output levels y_i.

In our data, the mean scale efficiency is at around 0.9, implying that there are some banks operating under scale inefficiency. Therefore, it justifies our choice of using various returns to scale DEA for our data.

Input-Output specifications for measuring technical efficiency

There are several approaches to the choice of inputs-outputs with respect to financial institutions that are widely employed in literature, including intermediation approach, production approach, value-added approach, and revenue approach (Berger & Humphrey, 1992; Drake, Hall, & Simper, 2009; Sealey & Lindley, 1977). In the production approach, banks are considered as firms that use labor and capital as factors of production, to produce loans and deposit accounts (Matthews & Thompson, 2005). Thus, only labor and physical capital (and their associated costs) should be included as inputs. In comparison, under the intermediation approach, based on work by Sealey and Lindley (1977), banks are regarded as intermediary connecting savers and investors. With this approach, interest cost and deposit should be counted as an input, as the deposit is the main "raw material" to be transformed in the intermediation process to create outputs (Berger & Humphrey, 1997). Both the production and intermediation approaches regard loans and other earning assets as outputs, and physical capital and labor as inputs. The two approaches are different in the way they treat deposits. The production approach does not account for interest cost, and sometimes regards a deposit as an output, while the intermediation approach considers deposit as an important input. The value-added approach, proposed by Berger and Humphrey (1992), on the other hand, distinguishes inputs and outputs according to their "value-added"

characteristics. Accordingly, the categories that use external sources of operating cost allocations, are employed as outputs (Berger & Humphrey, 1992) p.250. Thus, under this approach, deposits and loans are important outputs. Conversely, Drake et al. (2009) develop the revenue approach, which considers income (i.e interest income, and non-interest income) as outputs. In contrast, Hancock (1985) argues that it is possible to apply a model of production with monetary goods, besides the conventional physical resources of labor, capital, and materials. Accordingly, both the value-added and revenue approaches use interest and non-interest expenses as inputs. Hence, there is also a longstanding disagreement in the literature on whether the deposit should be categorized as inputs or outputs, as the deposit has both input and output characteristics (Berger & Humphrey, 1997). To solve this duality, as interest expenses are associated with "the role of deposits as providing the input of loanable funds" (Berger & Humphrey, 1997) p.251, Berger and Humphrey (1997) suggest that one can count interest expenses as an input and the rate paid as an input price, while including the quantities of deposits as an output.

This study employs the value-added approach, and treats deposits as both inputs and outputs. The reasons to specify a deposit as an output are that, first, in a typical bank, deposits could account for more than half of capital and labor expenses (Berger & Humphrey, 1992; Lozano-Vivas, Pastor, & Pastor, 2002). Second, the Vietnamese banking sector is very concentrated with five state-owned banks accounting for one half of the deposit and lending markets, and the remaining banks (including 28 commercial banks, 3 joint venture banks, and 5 foreign-owned banks in 2015) account for the remaining market. Thus, the private domestic commercial banks have to compete strongly with each other and with foreign banks to attract deposits. As a result, the competition even forces banks to devote more resources to attract customers.

Accordingly, we specify three outputs, and three inputs in Table 1.

Table 1: Inputs, outputs definition

Definition	Measurement
Outputs for the value – added approach	
Net customer loans (Y1)	= Total customer loans - provisions
Total deposits (Y2)	
Other earning assets (Y3)	= Total assets - y1- interbank lending - fixed assets
Outputs for the revenue approach	
Interest income (Y4)	
Other incomes (Y5)	= non-interest income + net income from other operating activities.
Inputs	

labor expenses (X1)	
non-interest expenses (X2)	= operating expenses – labor expenses – interest expenses
interest expenses (X3)	

It might be important to control for difference in the output quality among banks. Mester (1996), in a study of the efficiency of the US banks which employed stochastic frontier approach, uses the average volume of non-performing loans as an input to account for the quality of bank outputs and bank risk. Other researchers use loan loss provisions as an indicator of the extent of problem loans when the data of non-performing loans is not available (Drake & Hall, 2003). On the other hand, according to Berger and Mester (1997), whether it is appropriate to include loan losses or problem loans to the banks' cost and profit functions depends on whether they are exogenous (i.e. caused by negative external shocks like an economic downturn) or endogenous (i.e. caused by "bad management"). If the problem loans are exogenous, and if we fail to control for them, "then measured cost efficiency may be artificially low because of the expenses of dealing with these loans (e.g., extra monitoring, negotiating workout arrangements, etc.)" (Berger & Mester, 1997) (p. 194). Following Berger and Mester (1997) Drake et al. (2009) assume that the loan losses were due to "bad luck", therefore, included the loan loss provisions in the banks' cost as an input. On the contrary, we use the stock of loan loss provisions as a proxy if we consider high loan loss provisions in Vietnamese banks as a result of "bad management", which is consistent with the "bad management" hypothesis by Berger and DeYoung (1997). The reason we use loan loss provisions instead of non-performing loans to measure the loan quality is that the data on non-performing loans in the Vietnamese banks is unreliable. We also use the models proposed in Berger and DeYoung (1997) to confirm that the high loan loss provisions were due to "bad management" rather than "bad luck", which is reported in Appendix 1. Detail definitions of inputs and outputs are reported in Table 1.

The outputs and inputs are measured in billion VND and are adjusted by the GDP deflator, with 2010 as the base year. Tables 2 and 3 represent the descriptive statistics of inputs and outputs used for estimating technical efficiencies. Table 2 shows the movement over the years of inputs and outputs, which indicates the rapid and steady expansion of output quantities (i.e Y1, Y2, Y3). Accordingly, the income and expenses also increase over time. Additionally, Table 2 shows that Vietnamese banks are still primarily reliant on net interest income. The banks, however, expand other earning assets (including stock trading, gold trading on the asset side of the balance sheet) quicker than the traditional services (i.e lending). From 2008-2016, while lending quantities increase five times, other earning assets

go up seven times. This suggests that Vietnamese banks are trying to be less dependent on lending activities as the main source of income. It can be seen from Table 3 that state-owned banks dominate the banking system in terms of loans and deposits.

Table 2: Inputs, outputs evolution over time – mean and standard deviations (SDs) for 2008, 2011, 2013, 2016; SDs in brackets

Year	2008	2011	2013	2016
net customer loans	30,485	71,327	93,958	173,000
	(47724)	(97073)	(125900)	(224400)
total deposits	37,579	74,905	113,200	201,700
	(56260)	(89561)	(124400)	(239500)
other earning assets	17,302	40,972	49,030	114,600
	(25887)	(34170)	(41872)	(211200)
interest income	5,669	15,586	12,892	17,052
	(7545)	(16563)	(14105)	(18959)
other earning incomes	654	1,150	1,629	2,443
	(976)	(1559)	(2168)	(3455)
interest expenses	3,864	10,545	8,642	10,193
	(4904)	(11219)	(8987)	(11442)
Non-interest expenses	423	1,097	1,459	2,031
	(564)	(1161)	(1377)	(1991)
Labor expenses	459	1,138	1,278	2,134
	(803)	(1501)	(1527)	(2430)

Table 3: Descriptive statistics of variables used to estimate DEA technical efficiencies over the 9 years period

Variables	Observations			Mean	SD.	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
	All banks	State-owned banks	Private banks	All banks				State-owned banks				Private banks			
Outputs for the value – added approach															
Y1	225	27	198	89,600	137,000	328	850,000	386,000	194,000	129,000	850,000	49,200	50,900	328	262,000
Y2	225	27	198	104,000	143,000	738	864,000	400,000	198,000	145,000	864,000	64,300	68,300	738	351,000
Y3	225	27	198	49,200	83,400	417	1,070,000	130,000	59,700	60,700	263,000	38,200	80,200	417	1,070,000
Outputs for the revenue approach															
Y4	225	27	198	12,000	14,100	236	74,900	42,600	15,500	18,200	74,900	7,796	6,989	236	30,500
Y5	225	27	198	1,449	2,176	-864	12,800	6,191	2,732	1,970	12,800	803	948	-864	6,022
Inputs															
X1	225	27	198	1,211	1,627	24	8,843	4,714	1,913	916	8,843	733	785	24	4,084
X2	225	27	198	1,198	1,370	29	7,259	3,921	1,736	1,032	7,259	827	762	29	3,798
X3	225	27	198	7,651	8,763	87	46,600	25,500	10,300	6,626	46,600	5,213	4,864	87	24,300

Notes: Y1: Net customer loans; Y2: Total deposits; Y3: Other earning assets; Y4: Interest income; Y5: Other incomes; X1: Labor expenses; X2: Non-interest expense; X3: interest expense.

Methodology

DEA window analysis

DEA window analysis was first introduced by A. Charnes, Clarke, Cooper, and Golany (1985), which groups data on firms in several periods into a "window" and treats them as if they represent different firms (Yue, 1992). In particular, the "window" of size *s* at time *t*, is defined as a reference production set consisting of observations made from the point $s = t$ up to $s = t + s$ only (Tulkens & Eeckaut, 1995). As all DMUs within a given window are measured against each other, there is an implicit assumption that there is no technological change within the period covered by each of the windows (Asmild et al., 2004). Tulkens and Eeckaut (1995) generalize the window analysis, as a special case of a sequential reference production set. A sequential reference production set at each point in time *t* is constructed using the observations made from the point in time $s = 1$ up until $s = t$. This can be done by assuming that 'what was feasible in the past remains feasible for ever" (Tulkens & Eeckaut, 1995), p.480. However, there are some conditions influencing production possibility, such as regulation, competitive situation, economic conditions and so forth., which were possible in the past, but might not be possible today (Asmild et al., 2004), especially when the period is long. Therefore, the window analysis, with a properly narrow window width, seems to be a proper choice to capture the change in environmental variables. Furthermore, a narrow window width also seems to fit well into the assumption that there is no technological progress or regress within each of the windows. Therefore, in this study, we chose a three-year window, as adopted in many papers (Nguyen et al., 2014; Yue, 1992), forming seven windows (Table 4).

Table 4: Seven three-year window table

Window 1	2008	2009	2010						
Window 2		2009	2010	2011					
Window 3			2010	2011	2012				
Window 4				2011	2012	2013			
Window 5					2012	2013	2014		
Window 6						2013	2014	2015	
Window 7							2014	2015	2016

The window analysis is chosen in addition to the DEA in this study because it has some advantages. First, it can be used to study trends of the efficiency evaluations across as well as within windows (A. Charnes et al., 1985). Furthermore, the efficiency at a point in time can be calculated by averaging efficiency levels of the same bank across windows. In this sense, the mean efficiency of a bank has partly captured the change in technology over time, because

the bank appears in several windows with different frontiers. Second, the DEA window analysis artificially creates more 'degree of freedom' into the analysis (A. Charnes et al., 1985), as each bank appears in several windows. As a result, we get larger data sets for analysis than we would if we used single year frontiers.

Accounting for the effect of merger events

A major disadvantage of the DEA approach is that the parameters are not estimated using statistical methods, but calculated using mathematical programming techniques which precludes hypothesis testing (Murillo-Zamorano, 2004). Kneip, Simar, and Wilson (2003) introduced bootstrap procedures that derive the asymptotic distribution of DEA efficiency estimators under VRS, which allows one to perform consistent inferences regarding the efficiency in multiple inputs-outputs. However, the Kneip et al. (2003) approach does not account for environmental variables that are considered as factors constraining firms' choices of inputs and outputs. Coelli et al. (2005) state that not considering the difference in environmental factors - the factors that are not considered as traditional inputs, but could influence the efficiency of a firm - might lead to misleading results. Some of the factors can be mentioned such as ownership type, firms' age, or various management factors, for example, managers' characteristics, M&A event, or whether a bank goes public. Coelli et al. (2005) suggest several ways to accommodate "environmental" factors. In this study, we use the two-stage method account for those environmental factors and the single bootstrap proposed by Simar and Wilson (2007) as a robustness check. The two methods have the main advantage over other methods in that it is not an a priori requirement to make assumptions regarding the direction of the influence of the environmental variables (Coelli et al., 2005).

The two-stage approach is very popular in the literature (Simar & Wilson, 2011). Basically, the approach involves two stages: the first stage is to estimate DEA efficiency scores using only the traditional inputs and outputs; The second stage involves regressing the scores on the covariates identified as environmental variables using OLS or tobit models (Coelli et al., 2005). Nevertheless, Simar and Wilson (2007) criticize that the two-stage approach exposes to a serious problem that invalidates the method. The problem is the DEA efficiency estimates are serially correlated because the DMUs lying on the estimated frontier will cause the change in efficiency estimate of other DMUs. Therefore, the inference drawn from in the second stage regression results applied to finite numbers of observations are invalid due to the serial correlation problem of the estimate residuals (Simar & Wilson, 2007). As the correlation problem disappears in infinite samples, Simar and Wilson (2007) have developed two bootstrap procedures, namely the single and the double bootstrap procedures, that could increase the finite sample to a very large number, and therefore solve the problem of

correlation of the estimated residuals. In this study, we use the single bootstrap to find the true relationship between the environmental variables and the bank efficiencies. The method is illustrated in Appendix 2.

Hence, the true relationship between efficiency ∂ and environmental variables is given by:

$$\partial_i = \beta_1 merger + \beta_2 foreign\_ownership \quad + \beta_3 IPO + \beta_4 size + \beta_5 Zscore + \omega_j, j = 1, \dots, n$$

However, it is worthwhile noting that while the two-stage approach could be used for panel data, the bootstrap method is meant for use with cross-sectional data (Badunenko & Tauchmann, 2018). Therefore, in order to use the bootstrap method, we pool the data over time, implying that the technology has not changed over the study period. This is feasible because (i) the technology has not changed much as empirically seen in the following session (Table 7), using the DEA- Malmquist approach; (ii) the technological change has been partially captured in the technical efficiency estimated by the window analysis; (iii) the data has been inflated using the GDP deflator. By pooling the data in the nine-year period, we also implicitly test the long-term effect of M&A.

Data

The data is the balanced panel that is hand-collected from annual financial statements containing accounting and ownership data of Vietnamese commercial banks. Furthermore, using unbalanced data can introduce unnecessary noise which may influence the shape and position of the frontier in the DEA window analysis (Coelli et al., 2005); we only include banks and the period that there is no missing data. Furthermore, as we are looking at a balanced panel, we are only looking at acquiring banks, not the acquired ones. In the end, we have a balanced panel data from 25 commercial banks, covering the period 2008 to 2016, totalling 225 observations. There are three state-owned banks and 22 private banks in the sample. All selected banks are joint-stock commercial banks operating under the same regulatory environment. Likewise, all of the financial statements were reported based on the Vietnamese Accounting Standard (VAS). It is noteworthy that there were developments in VAS in recent years to be more in line with the principles of International Accounting Standards (IAS). Among the 25 banks, six banks were merged with other banks in the investigated period (Table 5). Details of which banks are included in the sample are provided in Appendix 3. The final sample represents 78.2% of the total assets of the Vietnamese banking sector as of 2016.

Table 5: Merger events

No	Year	Banks participated into the M&A	Banks after the M&A

1	2012	Sai Gon Commercial Bank, Ficombank, TinNghiabank.	Sai Gon Commercial Bank
2	2012	Habubank, Saigon Hanoi Commercial Bank	Saigon Hanoi Commercial Bank
3	2013	DaiABank, HDBank, Société Générale VietFinance (a finance company)	HDBank
4	2015	MDBank, Maritime Bank	Maritime Bank
5	2015	MHBank, BIDV	BIDV
6	2015	Southern Bank, Saccombank	Saccombank

It is required that the units under assessment using DEA need to be homogeneous (Dyson et al., 2001),; we include only domestic commercial banks in the sample. Foreign banks and ventured banks are excluded from the sample due to the lack of data as well as their limitations in approaching local customers.

5. Empirical results

The trend of technical efficiency over time

Table 6 shows the descriptive statistics for the technical efficiency levels employing the two approaches, the value-added approach and the revenue approach, for the different ownership types. The overall mean technical efficiencies of the Vietnam banks employing the two approaches, shown at the bottom of the Table, are relatively high and consistent, around 81% and 83% respectively. The technical efficiency level of 81.4% in the value-added approach implies that, on average, banks waste nearly 18% of their resources relative to the best-practice bank in the sample in generating the same amount of output quantities, given the same economic conditions. On the contrary, the 82.7% of technical efficiency level in the revenue approach shows that a typical bank, on average, uses around 17 % higher costs than the best-practice bank in generating the same revenue.

Table 6: Technical efficiency over the 2008-2016 period using DEA window analysis

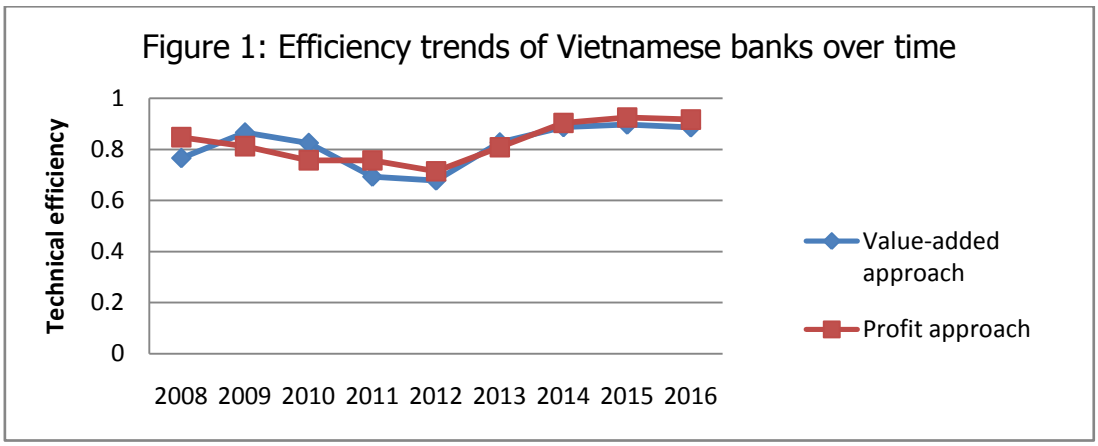
	Value-added approach			Revenue approach		
Year	State-owned banks	Privately owned banks	All banks	State-owned banks	Privately owned banks	All banks
2008	0.827	0.758	0.766	0.909	0.840	0.848
2009	0.995	0.849	0.866	1.000	0.787	0.813
2010	0.945	0.809	0.825	0.892	0.739	0.758
2011	0.763	0.683	0.693	0.929	0.734	0.757
2012	0.911	0.646	0.678	0.968	0.680	0.715
2013	0.901	0.817	0.827	0.943	0.791	0.809

2014	0.950	0.878	0.887	0.998	0.891	0.904
2015	1.000	0.883	0.897	0.995	0.916	0.926
2016	1.000	0.870	0.886	1.000	0.905	0.917
Mean efficiency	0.921	0.799	0.814	0.959	0.809	0.827
Mann-Whitney U-test hypothesis: Ho: there is no difference between the efficiencies of SOBs and POBs						
Z ratio	-4.096			-5.367		
P value	0.000			0.000		
Decision	Reject Ho at 1% level of significance			Reject Ho at 1% level of significance		

The mean efficiency of state-owned banks is, on average, higher than the efficiency of the privately-owned banks, at 0.921 and 0.959 respectively, compared to 0.799 and 0.809 respectively. To confirm this observation, we employ the non-parametric Mann-Whitney U test and the results show that the differences of the median efficiencies between the two groups are significant at the 0.1% level, which is consistent with the studies of efficiency of Vietnamese banks and Chinese banks such as (Berger, Hasan, & Zhou, 2009; Nguyen et al., 2014). This finding is interesting because the empirical work shows that state-owned banks are experiencing a decreasing return to scale[8] during the period. Some possible explanations for the relatively greater efficiency of the state-owned banks compared to the private banks is that, first, state-owned banks are regarded as safer than private banks, therefore, they can set lower interest rates than private banks meaning, relatively state-owned banks have advantages in costs over private banks. Second, state-owned banks are large banks and established much earlier than private banks, therefore they have many branches and customers all over the country. They therefore, have large numbers of deposit accounts as well as a large loans' volume. Third, the government might create a more favourable business condition to state-owned banks than private banks. There is no evidence that state-owned banks have market power in setting prices (i.e. setting prices higher than in private banks).

In terms of the movement over the nine years, Figure 1 shows that, overall, Vietnamese banks have experienced a minor improvement in technical efficiency levels since 2012.

[8] This result will be provided upon request.



There were two disruptions during the investigated period, in 2008 and the 2011-2012 period. The first disruption reflects the immediate negative shock of the global financial crisis in 2008, and the second one reflects the lagged effect of the global financial crisis and the European debt crisis on the Vietnam economy. In addition, there is a lag between the changes in technical efficiency in generating outputs' quantities and technical efficiency in generating revenue in 2008. In particular, the increase in the cost in 2008 led to the drop in revenue in 2009. From 2009 onwards, the technical efficiencies in the two approaches show similar patterns in the movement. These movements are also consistent with the findings by Nguyen et al. (2014) for the 1995-2011 period.

Technological change over the study period

In order to find whether there has been technological progress over the 2008-2016 period, we employed the output - based DEA Malmquist Productivity Index approach. Technological change is an economic concept capturing the technological progress[9] over time. Fare, Grosskopf, and Lovell (1994) specified a technological change (*tech_change*) between year *t* and *t*+1 as:

$$Tech\_change = \left[\left(\frac{D_0^t\left(x^{t+1}, y^{t+1}\right)}{D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)} \right) X \left(\frac{D_0^t\left(x^t, y^t\right)}{D_0^{t+1}\left(x^t, y^t\right)} \right) \right]^{1/2}$$

Where:

$D_0^t\left(x^t, y^t\right)$ is defined as the reciprocal of the maximum proportional expansion of the output vector y^t given the input vector x^t.

$D_0^t\left(x^{t+1}, y^{t+1}\right)$ is the distance function measuring the maximal proportional change in outputs required to make $\left(x^{t+1}, y^{t+1}\right)$ feasible given the technology at *t*.

$Tech\_change > 1$ indicating there is development in technology;

[9] The improvement in technology can come from the innovation of methods in using existing inputs, or through the improvement of input quality.

Tech_change = 1 if there is no technology progress;

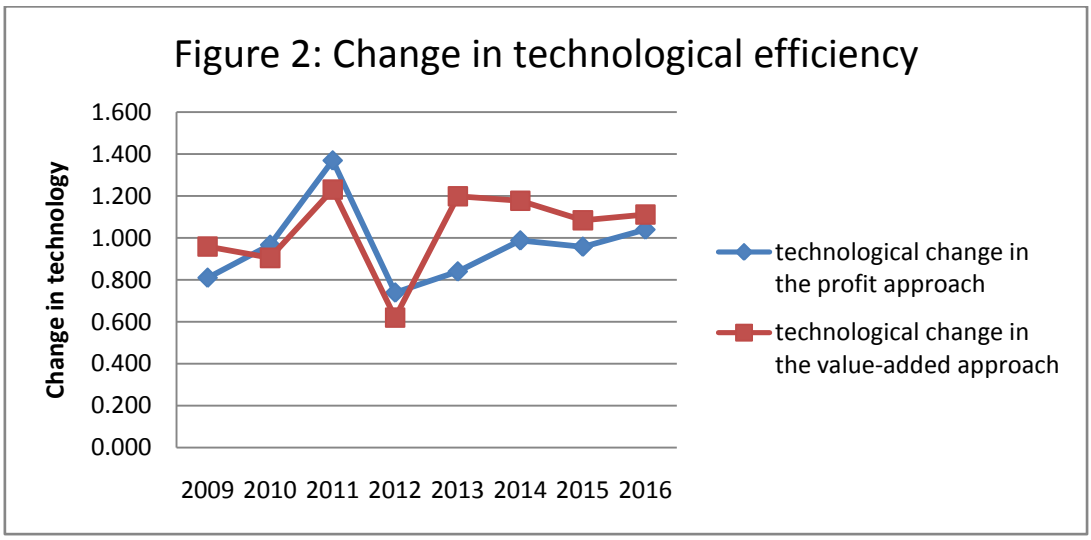
Tech_change < 1 indicating there is technical regress.

Results are reported in Table 7:

Table 7: Malmquist index summary of annual means

Year	2009	2010	2011	2012	2013	2014	2015	2016	Mean
Malmquist Index for the revenue approach									
Technological change	0.810	0.967	1.370	0.739	0.840	0.988	0.958	1.040	**0.949**
Technical efficiency change	1.169	1.061	0.700	1.197	1.176	1.014	0.993	0.977	1.023
Scale efficiency change	1.051	1.030	0.882	1.069	1.064	1.014	0.986	0.985	1.009
Total factor productivity change	0.947	1.026	0.959	0.885	0.988	1.001	0.951	1.016	0.971
Malmquist Index for the value – added approach									
Technological change	0.959	0.905	1.231	0.620	1.199	1.178	1.085	1.112	**1.015**
Technical efficiency change	1.386	0.984	0.658	1.380	1.104	0.984	0.997	0.985	1.035
Scale efficiency change	1.091	0.988	0.853	1.129	1.042	0.999	1.005	1.035	1.015
Total factor productivity change	1.329	0.890	0.810	0.855	1.324	1.160	1.082	1.095	1.051

As demonstrated in Table 7, overall, there is a minor technological change over the nine-year period[10], at -5,1% and 1,5% respectively over the nine years. In terms of technical efficiency change, the changes confirm what we have found in the main hypothesis test, meaning there were decreases in technical efficiency in 2008 and in 2011-2012. Regarding the change of technology over time in the two approaches, we can see they share the same trend, except for the year 2008, as presented in Figure 2, which reflects the increase in the cost in 2008 leading to the drop in revenue in 2009, as previously mentioned.



[10] However, looking closely there was technological regress in 2009, 2010, 2012 and 2013. This suggests that the technology used in the previous year becomes obsolete in the next year; in other words, those banks replace their old technology with new technology. This is reasonable given the fast speed in innovation of technology (i.e. informational technology or core banking) in the banking sector.

The impact of M&As

First, we employed the Mann-Whitney U test, and the results reported in Table 8 show that the differences of the median efficiencies between banks after M&As and banks without M&As are significant at the 5% level in the value-added approach, and at the 10% level at the revenue approach.

Table 8: Mann-Whitney U-test of the difference in the mean efficiency of banks with and without M&As

Revenue approach		**Value-added approach**	
Banks after M&As	Banks without M&As	Banks after M&As	Banks without M&As
Mean efficiency		Mean efficiency	
0.99	0.822	0.887	0.809
Mann-Whitney U-test hypothesis:			
Ho: there is no difference between the efficiencies of banks with M&As and banks without M&As		Ho: there is no difference between the efficiencies of banks with M&As and banks without M&As	
Z ratio	-1.945	-2.016	
P value	0.052	0.044	
Decision: Reject Ho at 10% level of significance		Reject Ho at 5% level of significance	

To further confirm the findings, we empirically tested the impact of M&As on the Vietnamese bank technical efficiencies, employing the Tobit and Truncated regression (because technical efficiencies estimated in the previous section have the boundary of [0,1]). Following Berger and Mester (1997), we identified five environmental variables that might influence the efficiency scores, hence, the second stage regression is given by:

$$\partial_{i,t} = \beta_0 + \beta_1 merger_{i,t} + \beta_2 foreign\_ownership_{i,t} + \beta_3 IPO_{i,t} + \beta_4 size_{i,t} + \beta_5 ownership_{i,t} + \beta_6 Zscore_{i,t} + \beta_7 GFC_{i,t} + \beta_8 EDC_{i,t} + \omega_{i,t}$$

We also used the results from the single bootstrap as a robustness check. As the bootstrap technique proposed by Simar and Wilson (2007) applies for cross-sectional data, we pool the data in the study period. Therefore, the regression model shows as below:

$$\partial_i = \beta_0 + \beta_1 merger + \beta_2 foreign\_ownership + \beta_3 IPO + \beta_4 size + \beta_5 ownership + \beta_6 Zscore + \beta_7 GFC + \beta_8 EDC + \omega_j, \quad with\ j = 1, \dots, n$$

Where:

∂: represents the efficiency scores, estimated in the window analysis in the previous section.

Merger: is a dummy variable, equals 1 if the bank merges with another bank in that year or any previous years, and 0 otherwise.

Other controlling variables are:

$foreign\_ownership$: is a dummy variable, equals 1 if domestic banks have minority ownership (less than 20% of total equity according to the Vietnamese law) owned by a foreign entity in that year and the following; and 0 otherwise;

ownership: is the dummy variable, equals 1 if banks are a private bank; and 0 otherwise;

IPO: is a dummy variable, equals 1 if banks are listed on stock markets; and 0 otherwise;

$size$: is calculated as the log of total assets. Total assets are measured in million VND;

$Zscore$: is a measure of bank insolvency risk. A higher Z score implies a higher probability of solvency.

$Zscore_{i,t} = \frac{ROA_{i,t}+CAR_{i,t}}{\partial_{ROA\ t}}$. ∂_{ROA_t} is the standard deviation of ROA in year t, over the sample.

Financial_crises: are dummy variables, which include two financial crises; one is the global financial crisis from 2008-2009 (GFC) and the other is the European debt crisis from 2011-2012 (EDC).

w_{it} : is the random variable.

The results employing the tobit, truncated and bootstrap techniques are reported in Table 9. Unlike the tobit, the truncated and bootstrap regressions exclude the observations that the technical efficiency equals one (full efficiency), as even though the full efficiency is technically possible, it happens with zero probability (Badunenko & Tauchmann, 2018). In addition, the year fixed effect is not included in all the regressions as the data used for measuring the technical efficiencies has been deflated[11]. As can be seen from the Table, the results from the truncated and bootstrap methods are almost the same (except for some minor differences in the p-value), however different from the one using the tobit method. It is because, in the tobit regression, the observations having full efficiency are included. If we exclude those full efficiency observations, the tobit regression would deliver the same result as the truncated and bootstrap methods.[12].

The negative significant coefficients of the merger dummy, and the positive significant coefficients of the interaction term between the merger dummy and the IPO dummy in Models 4 and 6 suggest that, even though banks have a tendency to experience a lower efficiency after the mergers, listed banks experience a better efficiency after the mergers than

[11] Even including the year fixed effects and firm fixed effect, the results are still robust.
[12] The result will be provided upon request.

unlisted banks. However, these results are only statistically significant in the value-added approach, and not significant in the revenue approach. The finding confirms what we have predicted in that M&A decrease the efficiency of the combined bank. It might be explained by the costs incurred to the combined bank associated with resolving bad debts which were transferred from the weak bank. Owing to the nature of Vietnamese M&As where the merging banks were not necessarily efficient, it is reasonable to not witness an increase in efficiency after the M&A. The difference in performance between listed and unlisted banks after merger events might be explained by the difference in governance between listed banks and unlisted banks. Different from unlisted banks, listed banks are operating under the Securities Law 2006 and the Code of Corporate Governance of listed companies[13] (Code) as a subordinate legal document under the Securities Law. The principles of the code aim to ensure (i) an effective managerial structure; (ii) the rights of shareholders; (iii) fair and impartial treatment between shareholders; (iii) an effective management by board of management and control board; (v) preventing conflicts of interest and related party transactions; and (vi) information disclosure and transparency. Subject to these regulations, listed banks, therefore, are likely to have a better and more transparent management than unlisted banks. As a result, listed banks could improve the operation of the newly-formed banks better than unlisted newly-formed banks. As the majority of income Vietnamese banks earn come from lending activities, Vietnamese banks are motivated to attract deposits and increase their lending, because after merging with a weak bank, the newly-formed bank would have more room to increase lending. As a result, we see the better efficiency experienced by listed banks than unlisted banks in generating output quantities (the value-added approach) after an M&A. However, we do not find the evidence of efficiency improvement in generating income (the revenue approach). This is because the Vietnamese banks incurred a huge loss in the stock and gold trading markets during the 2010-2012 period. The finding confirms the consensus among researchers that for banks to benefit more from M&As, the acquiring bank needs to be more efficient than the acquired bank. The result also provides evidence that banks in Vietnam seek to increase customer bases and market outreach through M&As.

It is interesting that the coefficient for foreign ownership has a significant negative sign in the value-added approach (Model 1-6) and is not significant in the revenue approach (Model 9-12). This suggests that given the output quantities (i.e. loans, deposits, and other earning

[13] Decision No. 12/2007/QD-BTC of March 13, 2007, promulgating regulations on corporate governance applicable to companies listed on the stock exchange or a securities trading centre. The Vietnamese Government issued a new code on corporate governance in 2017 (Decree 71/2017/ND-CP).

assets), banks become less efficient in controlling costs after taking on foreign ownership. This might be explained given the Vietnamese context. In Vietnam, foreign investors are restricted to hold up to 20% of the total shares of any domestic bank. In such cases, foreign investors usually assign a delegate to sit on the local bank's board or management to represent their rights (so-called "minority foreign ownership"). In return, foreign directors are committed to assisting the local bank in modern technology transfer, developing banking products and services, and raising financial, administration and risk management capabilities. Therefore, in the short run, those banks incur relatively more costs relating to upgrading technology, training local staff, enhancing risk management system etcetera, than other banks, which results in the negative relationship between foreign ownership and technical efficiency. This finding is in contrast to several studies, which found that minority foreign ownership improves banks' efficiency (Berger et al., 2009; Sun, Harimaya, & Yamori, 2013). However, those studies use cost and profit efficiencies, which take into account the price of inputs and outputs, as the measurement of efficiency; while this study uses technical efficiency, which does not take into account the prices.

In terms of ownership, the finding is consistent with what we have found using the Mann-Whitney U test in the previous session, showing that state-owned banks are more efficient in operation than private banks. In addition, the positive relationship between Z score and technical efficiency are strongly significant in both models, suggesting that good managers are good at both operations and risk management. The finding is also consistent with Berger and Mester (1997). Additionally, unlike the belief from the Vietnamese government that Vietnam was not much impacted by the 2008 global financial market, the result shows that external negative shocks could have a strong negative impact on the performance of Vietnamese banks.

Table 9: The effect of merger on technical efficiency

	Value-added approach						Revenue approach					
Variables	Tobit	Tobit	Truncated	Truncated	Bootstrap	Bootstrap	Tobit	Tobit	Truncated	Truncated	Bootstrap	Bootstrap
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Merger	0.0929	0.0711	-0.0605	-0.212**	-0.0605	-0.212**	0.0905*	0.124*	0.0493	0.0730	0.0493	0.0730
	(1.88)	(1.07)	(-0.85)	(-2.35)	(-0.86)	(-2.27)	(1.90)	(1.92)	(0.52)	(0.50)	(0.51)	(0.38)
Merger X IPO	-	0.0463	-	0.313**	-	0.313**	-	-0.0698	-	-0.0399	-	-0.0399
	-	(0.49)	-	(2.29)	-	(2.05)	-	(-0.77)	-	(-0.22)	-	(-0.17)
IPO	-0.0393	-0.0435	-0.0101	-0.0272	-0.0101	-0.0272	-0.0632**	-0.0566**	-0.0670	-0.0650	-0.0670	-0.0650
	(-1.45)	(-1.53)	(-0.31)	(-0.84)	(-0.31)	(-0.87)	(-2.36)	(-2.02)	(-1.60)	(-1.52)	(-1.66)	(-1.55)
Foreign_ ownership	-0.0612**	-0.0592**	-0.0630**	-0.0599**	-0.0630**	-0.0599**	-0.0483**	-0.0515**	-0.0492	-0.0500	-0.0492	-0.0500
	(-2.53)	(-2.41)	(-2.14)	(-2.09)	(-2.17)	(-2.11)	(-2.04)	(-2.15)	(-1.31)	(-1.33)	(-1.33)	(-1.35)
ownership	0.220***	0.221***	0.265***	0.269***	0.265***	0.269***	0.243***	0.241***	0.369***	0.368***	0.369***	0.368***
	(4.88)	(4.90)	(3.84)	(4.01)	(3.71)	(4.00)	(5.35)	(5.32)	(2.96)	(2.95)	(2.88)	(2.77)
size	-0.0110	-0.0108	-0.0724	-0.0703	-0.0724	-0.0703	0.0506	0.0503	0.0538	0.0538	0.0538	0.0538
	(-0.29)	(-0.29)	(-1.57)	(-1.57)	(-1.58)	(-1.66)	(1.39)	(1.38)	(0.93)	(0.93)	(0.96)	(0.95)
Zscore	0.00357**	0.00355**	0.00477**	0.00473**	0.00477**	0.00473**	0.0058***	0.0059***	0.0087***	0.0087***	0.0087***	0.0087****
	(2.37)	(2.36)	(2.38)	(2.42)	(2.41)	(2.44)	(3.96)	(3.98)	(3.19)	(3.19)	(3.22)	(3.31)
EDC	-0.169***	-0.169***	-0.199***	-0.196***	-0.199***	-0.196***	-0.0893***	-0.0892***	-0.134***	-0.134***	-0.134***	-0.134***
	(-5.83)	(-5.84)	(-5.68)	(-5.77)	(-5.72)	(-5.92)	(-3.15)	(-3.15)	(-3.04)	(-3.04)	(-3.16)	(-3.15)
GFC	-0.0563*	-0.0567*	-0.105***	-0.105***	-0.105***	-0.105***	0.00112	0.00192	-0.0532	-0.0529	-0.0532	-0.0529
	(-1.74)	(-1.75)	(-2.60)	(-2.67)	(-2.58)	(-2.80)	(0.04)	(0.06)	(-1.03)	(-1.02)	(-1.04)	(-1.03)
Constant	0.905***	0.904***	1.377***	1.361***	1.377***	1.361***	0.361	0.362	0.349	0.349	0.349	0.349
	(2.94)	(2.94)	(3.66)	(3.72)	(3.67)	(3.93)	(1.20)	(1.20)	(0.74)	(0.74)	(0.76)	(0.76)
Sigma	0.154***	0.153***	0.145***	0.142***	0.145***	0.142***	0.150***	0.150***	0.171***	0.171***	0.171***	0.171***
	(18.44)	(18.44)	(12.91)	(13.09)	(13.45)	(13.53)	(18.77)	(18.77)	(10.73)	(10.73)	(11.37)	(11.13)
N	225	225	183	183	183	183	225	225	186	186	186	186

t statistics in parentheses and * p<0.1 ** p<0.05 *** p<0.01

6. Conclusion

The study explores the effect of M&As on technical efficiency in the Vietnamese banks. The study utilizes the DEA window analysis to estimate technical efficiency and various regressions (tobit, truncated and bootstrap) to explore the relationship between M&As and the estimated technical efficiency. The findings are as follows. The technical efficiency in the Vietnamese banking sectors in the 2008-2016 period is quite high, with an average of 0.82. The results are similar in both value-added approach and revenue approach, implying that given the outputs, Vietnamese banks on average could save 18% of the costs to achieve full efficiency, which is similar to Vu and Turnell (2010). In addition, state-owned banks experience higher efficiency than private banks, which is consistent with Nguyen et al. (2014). Regarding the effects of M&As on efficiency, the mergers in the Vietnamese context do not cause an increase in efficiency, rather they lead to a decrease in efficiency after the mergers in unlisted merging banks. This is because the mergers did not come from the outstanding banks taking over the weak banks, but were induced by the restructuring program proposed by the government. However, there is evidence that listed banks have experienced better post-merger performance, which can be explained by the better transparency and management control in listed banks. The results are robust in tobit, truncated and bootstrap methods.

This study contributes to the literature in two important ways. First, it expands the limited existing literature on the impact of M&As from a developing country perspective. It also provides the background of the M&As in Vietnam with its distinctive characteristics, and illustrates how institutional factors could influence the expected result. Second, it informs the government about the effects of M&As. Perhaps the government should promote mergers between more efficient banks with weak banks, because it creates the channel for operation improvement, instead of letting banks merge just because they have the same big owners. On the other hand, letting foreign entities be involved in the banking restructuring process would be a good idea, because they have superior management skills, which would benefit the local market.

The study, however, faces some difficulties that limit its scope. First, the sample period of investigation is not long, and the number of mergers is limited. Vietnam is in its second phase of restructuring the banking sectors, and is now promoting the mergers between healthier banks. This creates an opportunity for a similar study in the future, with more observations, to compare and contrast the effect of M&As with respect to different motives by banks. Second, it could be more insightful to compare and contrast the effect of M&As in Vietnamese banks

with banks in other countries with similar banking development, for example, the Philippines, Indonesia, Malaysia, and China. This would provide evidence how different institutional settings such as regulations, the development of the financial markets, and the markets for high profile managers, would affect the outcome of M&As. These limitations await future studies to address.

Appendix 1: Testing the "bad management" hypothesis vs "bad luck" hypotheses

According to the "bad management" hypothesis, the low measured efficiency is the result of poor management practices by senior managers, including managing day to day operations and the loan portfolio. The poor monitoring practices, as a result, leads to a high number of non-performing loans. Thus, under the bad management hypothesis, the low efficiency is expected to occur before non-performing loans. As a result, we would expect the significant negative relationship between the lag values of efficiency and non-performing loans. In contrast, the "bad luck" hypothesis states that external events (e.g. global financial crisis, the European debt crisis) have a negative spill-over effect on the economic conditions, hence, leads to an increase in non-performing loans. As a result, banks begin to spend extra operating costs dealing with these problem loans. As most of the costs, for example, the costs associated with loan workout and default, are incurred after the increase in the problem loans, we would expect the significant negative relationship between lag values of non-performing loans and efficiency. In the Vietnamese bank context, the ratio of loan loss provisions to total loans is used as a proxy for the extent of non-performing loans. Accordingly, we have two fixed effect regressions as below. As the data is deflated, the year effect is excluded from the regressions.

The bad management model:

$$LLP_{i,t} = LLP_{i,t-1} + Effiency_{i,t-1} + CAR_{i,t} + LTD_{i,t} + \varepsilon_{i,t} \ (I)$$

The bad luck model:

$$Effiency_{i,t} = Effiency_{i,t-1} + LLP_{i,t-1} + CAR_{i,t} + LTD_{i,t} + \varepsilon_{i,t} \ (II)$$

Where:

LLP: is loan loss provision-to-customer loan ratio;

Efficiency: is the efficiency scores estimated by DEA window analysis;

Two controlling variables are:

CAR: is total equity-to-total asset ratio;

LTD: is loan-to-deposit ratio.

The results are reported in Table 1 below:

Table 1: Bad management hypothesis vs bad luck hypothesis

Variables	Model I		Model II	
	LLP (1)	LLP (2)	Efficiency_1 (Value-added approach) (3)	Efficiency_2 (Revenue approach) (4)
Lag 1 of LLP	0.495***	0.489***	1.791	3.777*
	(9.58)	(9.48)	(1.04)	(2.30)
Lag 1 of efficiency_2	-0.00533*	-	-	0.458***
	(-2.47)	-	-	(6.67)
Lag 1 of efficiency_1	-	-0.00561**	0.358***	-
	-	(-2.67)	(5.12)	-
CAR	0.0136	0.0127	-0.385	-0.345
	(1.51)	(1.41)	(-1.29)	(-1.21)
LTD	-0.00159	-0.00125	-0.0930	-0.0511
	(-0.79)	(-0.62)	(-1.37)	(-0.79)
Constant	0.0111***	0.0111***	0.627***	0.480***
	(4.29)	(4.45)	(7.53)	(5.85)
N	200	200	200	200

t statistics in parentheses *p<0.05; ** p<0.01; ***p<0.001

As can be seen from Table 1, the results of (1) and (2) suggest that the loan loss provisions have a significant negative relationship with the first lag of the efficiency, indicating that low efficiency leads to higher loan loss provision- to-customer loan ratio. The relationship is robust in both methods estimating efficiency (i.e. value-added approach and revenue approach). These results support the bad management hypothesis (Model I). The results of Model II, on the other hand, do not support the bad luck hypothesis. The positive coefficients in (3) and (4) suggest that the higher the loan loss provision-to-customer loan ratio, the higher the efficiency, which is contradictory to what the bad luck hypothesis predicts.

Appendix 2: Bootstrap method proposed by Simar and Wilson (2007)

Simar and Wilson (2007) propose the two bootstrap procedures[14], namely single bootstrap and double bootstrap, to overcome the serial correlation problem which occurs among efficiency scores, thus yields consistent inference of the second stage regression (i.e. the relationship between the environmental variables and efficiencies). The double bootstrap is preferable, but both can be used for robustness checks (Simar & Wilson, 2007). Following Simar and Wilson (2007) and Badunenko and Tauchmann (2018), the single bootstrap employed to estimate technical efficiency can be generalized as below:

- The production function has the below form:

$$\boldsymbol{F} = \{(\boldsymbol{x}, \boldsymbol{y}) \in \boldsymbol{R}_{+}^{\boldsymbol{N}} \times \boldsymbol{R}_{+}^{\boldsymbol{M}} : x\ can\ produce\ y\}$$

As the population F is unobserved, the output oriented technical (in) efficiency of DMU i, we cannot obtain the true value of efficiency ∂; instead, the $\hat{\partial}$ is estimated using DEA on the sample f, which is sub of F.

- We also assume the true relationship between efficiency ∂ and environmental variables is given by:

$$\partial_i = Z_j \beta + \omega_j, j = 1, \dots, n$$

Where Z_j is a row vector of firm-specific variables that are expected to influence the efficiency. As we can obtain only $\hat{\partial}$, instead of ∂, the $\hat{\partial}$ is used in a truncated regression (left truncated at 1) of $\hat{\partial}_t$ on Z_j to obtain coefficient estimates of β (called $\hat{\beta}$) and the estimated standard deviation of the error term ω (called $\hat{\sigma}_\omega$).

- Loop over the following steps in order B times, in order to obtain a set of B bootstrap estimates $(\widehat{\beta^b}, \widehat{\sigma_\omega^b})$, with b = 1,….,B

- For each DMU i = 1, . . . , M, draw an artificial error $\hat{\sigma}_{\omega i}$ from the truncated N(0, $\hat{\sigma}_\omega{}^2$) distribution with left-truncation at $1 - Z_j \beta$.
- Calculate artificial efficiency scores $\hat{\partial}_i$ as $Z_j \hat{\beta} + \hat{\sigma}_{\omega i}$ for each DMU i = 1, . . . , M.
- Run a truncated regression (left-truncation at 1) of $\hat{\partial}_i$ on Z_j to obtain maximum likelihood, bootstrap estimates $\widehat{\beta^b}$ and $\widehat{\sigma_\omega^b}$.

- Lastly, calculate confidence intervals and standard errors for $\hat{\beta}$ and $\hat{\sigma}_\omega$ from the bootstrap distribution of $\widehat{\beta^b}$ and $\widehat{\sigma_\omega^b}$.

[14] In essence, the bootstrap technique is used to increase the sample size by resembling a dataset with replacement.

Appendix 3: Vietnamese banks included in the sample, from 2008-2011.

No.	Banks
1	Eximbank
2	Nam A Bank
3	An Binh Bank
4	BIDV
5	Quan Doi Bank
6	Lien Viet Bank
7	Saigon Commercial Bank (SGB)
8	Vietinbank (CTG)
9	Vietnam Thinhvuong Bank (VPB)
10	Vietcombank (VCB)
11	A Chau Bank (ACB)
12	Techcombank
13	Nam Viet Bank (NVB)
14	TienPhong Bank (Tpbank)
15	Saigon Bank (SCB)
16	Hdbank (phat trien nha HCM)
17	Vietcapital Bank (Ban Viet)
18	Vietnam International Bank (VIB)
19	SEA Bank (NH Dong Nam A)
20	SHB (sai gon - hanoi)
21	Saccombank (STB)
22	Maritime Bank (MSB)
23	Oricombank
24	Kien Long Bank
25	Petrolimex Bank (PGbank)

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