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# The Cost Efficiency of Cambodian Commercial Banks:

## A Stochastic Frontier Analysis

Hidenobu Okuda\* and Daiju Aiba†

### Abstract

Regulating a banking sector requires a deep understanding of the industry structure and behavior of banks, and their current market performance. The Cambodian banking sector has rapidly expanded in recent decades, in line with the Country's sustained high economic growth. However, there are concerns about the performance of Cambodian banks and the country's banking sector. The problem is that there is a paucity of empirical evidence to clarify the real issues in the banking sector, and this lack of evidence also makes it difficult to formulate effective policy measures to address any potential problems. In this study we provide empirical evidence on the behavior of Cambodian commercial banks by estimating the industry cost function and their cost efficiencies. Our study covers 34 commercial banks over the period from 2012 to 2015. We find that average cost efficiency scores range from 0.26 to 0.29 (depending on the output definition) for Cambodian commercial banks, suggesting that if they operated more efficiently they could cut costs by 71% to 74% while keeping the same output level. We also find that the Cambodian banking industry realizes economies of scale. Furthermore, by estimating the determinants of cost efficiency we find that expanding a branch network into local areas is inefficient for bank management. Secondly, holding excessive liquidity is associated with greater inefficiency, but diversification in bank business operations is positively associated with the improved cost efficiency of Cambodian commercial banks.

**Keyword:** Cambodia, Cost Function, Efficiency, Banking, Stochastic Frontier Analysis

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## **1. Introduction**

The Cambodian government has conducted continuous structural reforms of the financial sector to achieve the efficient mobilization and appropriate allocation of both domestic and foreign funds (Ty 2007; IMF 2011, 2018). Although the Cambodian economy seems to have been entering into a steady growth phase, further efforts must be made to transform its economic structure to make market mechanisms more efficient. From this viewpoint, enhancing the functions of the financial sector is essential for the further development of the economy.

Supported by favorable macroeconomic conditions, the size of the Cambodian banking sector has been expanding rapidly since the late 2000s. The National Bank of Cambodia (NBC), the country's central bank, has been making strenuous efforts to improve the functions of the banking sector, while pushing ahead with deregulation to establish a more liberal market. However, there are problems emerging with these moves. For instance, there is concern about so-called over-banking, i.e., excessive numbers of banks largely due to an increase in the number of small-scale banks. Another problem is the inefficient intermediation practices of the commercial banks due to their excessive liquidity holdings. In addition to having to maintain the required reserve ratio at 10%, Cambodian banks have a large amount of excess reserves. This behavior may be a consequence of dollarization, as this limits the central bank's lender-of-last-resort function (Delechat et al. 2012). These circumstances have significantly reduced the efficiency of the Cambodian commercial banks' financial intermediation activities. Therefore, systemic reform is necessary to address these issues (Unteroberdoerster 2014).

To address these problems, it is necessary to rigorously understand bank behavior from an empirical perspective. However, there have been few econometric analyses examining bank behavior and the structure of the Cambodian banking sector. Although there are cross-country studies which estimate the cost and profit functions of banks (Nguyen 2018), Okuda and Aiba

(2016) is the only single-country study which has investigated the efficiency of Cambodian banks. Since their study used data envelopment analysis (DEA) (a non-parametric approach), it is not free from the limitations of such an approach in that it cannot specify the functional form of production technology in verifying the operational characteristics of the banking industry.

The purpose of the present study is to estimate the cost function of Cambodian commercial banks using parametric estimation techniques to investigate the technological characteristics of the banking industry. From our empirical analysis, we find the Cambodian commercial banks are on average only 26-29% efficient. This means it could produce the current level of output with 71-74% less costs, thus a great deal of inefficiency is observed in Cambodian commercial banking. We also find that the economies of scale and scope exist the Cambodian banking industry. Furthermore, by estimating the determinants of the cost efficiency of Cambodian commercial banks, excessive liquidity affects inefficiency greatly, and its influence is largest among the explanatory variables in our empirical model. Secondly, diversifying management practice would be effective in increasing the cost efficiency of the Cambodian commercial banks. Thirdly, expanding a branch network into local areas is inefficient for bank management. Lastly, the amount of capital procured from abroad is not associated with the cost efficiency of the Cambodian commercial banks.

The structure of this study is as follows. Section 2 explains the Cambodian banking system briefly and provides an overview of the management characteristics of commercial banks in Cambodia. Section 3 explains the methodology of the stochastic frontier analysis technique to measure efficiency and technological changes of major commercial banks in Cambodia. Section 4 discusses the operational characteristics of individual banks focusing on efficiency, the scale and scope of business operations, and ownership attributes based on the results of our estimation. It also estimates the determinants of efficiency. Finally, Section 5 summarizes the characteristics of

bank management in Cambodia clarified by this paper and draws several policy implications for enhancing banking sector performance.

## **2. Financial sector in Cambodia**

The National Bank of Cambodia was established in 1954. However, the Cambodian banking sector was completely destroyed between 1975 and 1979 under the Pol Pot regime, and the use of the Cambodian currency, the riel, was suspended. The National Bank of Cambodia was reconstructed in 1979 as a central bank after the collapse of the Pol Pot regime and the Foreign Trade Bank resumed commercial banking services as a bank wholly owned by the government. Cambodia reintroduced its currency, the riel, in 1980 and started to make the transition from a planned to a market economy in 1991. After the start of this transition, private commercial banks were established as joint-ventures with the National Bank of Cambodia or as a branch of a foreign bank. By 1998, 32 commercial banks had been established and these were mostly Cambodian local banks in a joint venture with foreign private capital.

The National Bank of Cambodia launched large-scale reforms in 1998. Financial institutions in Cambodia were classified into three categories: commercial banks with a minimum paid-up capital of US\$13 million, specialized banks with a minimum paid-up capital of US\$2.5 million, and licensed and registered microfinance institutions. At the same time, sound management of financial institutions was restored, the bad assets of the National Bank of Cambodia were depreciated, and the number of financial institutions decreased by half through restructuring.<sup>1</sup>

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<sup>1</sup> The reforms of financial institutions were conducted in series. The Foreign Trade Bank of Cambodia became independent and was privatized in 2005 to make the banking system sound and more transparent. At the same time, the required amount of capital of a commercial bank was increased to US\$38 million to boost the credibility of these banks in their rapid (excessive) growth and to cope with inflationary pressures.

Laws governing banks and financial institutions stipulate that banking services consist of three types of services: (1) credit services, including leasing business and guarantee business; (2) absorption of savings from the general public; and (3) provision of the means of payment and settlement for businesses, both in local and foreign currencies. Commercial banks are financial institutions that handle all these types of services, and specialized banks are financial institutions that are allowed to conduct only loan business. Microfinance institutions are financial institutions that are allowed to do business only in a specific area to a limited extent, though they can conduct both savings and loan businesses. In terms of their legal form, banks in Cambodia are classified into two types: Cambodian local banks and Cambodian branches of foreign banks. In this framework, Cambodian local banks include wholly-owned foreign banks, joint venture banks with local capital, and subsidiaries of foreign banks.

In the Cambodian banking sector, there are several challenges (NBC 2016). First, the Cambodian economy is highly dollarized and the rate of financial dollarization that is measured in terms of dollar deposit ratio is as high as 95%. In transactions on a cash basis, the dollar is used widely. Secondly, the financial network is undeveloped in Cambodia. Banks are concentrated only in Phnom Penh and some other major cities. While a few banks do have a nationwide branch network that covers local areas, financial inclusion is still low and the number of people who can use banks is limited, with settlement mostly in cash. Thirdly, due to a lack of short-term money and other securities markets it is problematic for financial institutions to adjust the amount of surplus (or shortage) of funds flexibly and this impedes financial transactions. Fourthly, the clearinghouse has only limited functions and the clearing system insufficient because the nationwide system is still undeveloped.

The IMF (2011) evaluated the performance of the Cambodian financial sector affirmatively in terms of three aspects: the recent development of measures to strengthen and

improve the soundness of banks; the increased transparency in bank management with ongoing development of the use of internal ratings; and the consistent efforts to ease exchange regulations and capital transactions. However, for the banks that play a central role in the Cambodian financial sector, the aforementioned IMF report points to three problems: banks are not necessarily given enough confidence, banks are not easily accessible in local areas, and small- and medium-sized companies face restrictions in borrowing because of high interest rates. At the same time, the report points out that bank management is fragile because financing depends on foreign capital and expanding potentially bad debts is risky against the background of rapid growth of real estate investment. As fundamental problems, the IMF refers to the limited ability of the banks to evaluate risks involved in financing, the shortage of human resources, and the seriousness of continuing to have underdeveloped accounting systems.

### **3. Estimation of Cost Function and Inefficiency of Cambodian Commercial Banks**

#### **3.1 Empirical Model**

In this section, we estimate the cost function of Cambodian commercial banks using stochastic frontier analysis<sup>2</sup>. Here, we attempt to reveal how much inefficiency exists in the operations of the Cambodian commercial banks by adopting the approach proposed by Battese and Coelli (1992). This empirical model is designed for estimating the chronological technological change in the Cambodian banking sector. We also examine whether economies of scale and scope are being realized. We estimate the following trans-log cost function to carry out this analysis:

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<sup>2</sup> Studies of bank efficiency now increasingly also look at profit efficiency (for example, Nguyen 2018). However, our study focuses exclusively on estimation of the cost function, since cost minimization and profit maximization are essentially equivalent under the standard assumptions of firms' behavior.

$$\begin{aligned}
\ln(TC_{it}/w_{2,it}) &= \alpha_0 + \sum_{j=1}^2 \alpha_j \ln(Q_{j,it}) + \sum_{k=1}^2 \beta_k \ln(w_{k,it}/w_{2,it}) \\
&+ \frac{1}{2} \sum_{k=1}^2 \sum_{m=1}^2 \theta_{km} \ln(w_{k,it}/w_{2,it}) \ln(w_{m,it}/w_{2,it}) \\
&+ \frac{1}{2} \sum_{j=1}^2 \sum_{n=1}^2 \gamma_{nm} \ln(Q_{j,it}) \ln(Q_{n,it}) \\
&+ \frac{1}{2} \sum_{m=1}^2 \sum_{n=1}^2 \delta_{mn} \ln(w_{m,it}/w_{2,it}) \ln(Q_{n,it}) + \tau_t + u_{it} + \epsilon_{it}
\end{aligned} \tag{1}$$

where:  $TC_{it}$  denotes total cost of bank  $i$  in period  $t$ ,  $Q_{j,it}$  represents output value of product  $j$ , and  $w_{k,it}$  represents the price of inputs. We normalize input price and total cost by  $w_{2,it}$  (capital price) in order to assume the homogeneity of degree one in factor prices.  $\epsilon_{it}$  is the error term which follows a normal distribution with variance  $\sigma_\epsilon^2$  and mean 0. In addition, to examine changes of the cost function over time due to technological change, we incorporate a year dummy  $\tau_t$  in the cost function. Assuming the symmetry of parameters of the cross term, we put restrictions on parameters as  $\gamma_{nm} = \gamma_{mn}$  and  $\theta_{km} = \theta_{mk}$ . We also set  $\delta_{mn} = 0$  ( $m, n = 1, 2$ ) with the assumption of separability between input prices and products.

We use  $u_{it}$  as the stochastic variable to represent inefficiency, and assume the following structure in-line with Battese and Coelli (1992) for the distribution of inefficiency  $u_{it}$ :

$$u_{it} = \exp\{-\eta(t - T_i)\} * u_i \tag{2}$$

$$u_i \sim N^+(\mu, \sigma_u^2) \tag{3}$$

We assume that  $u_i$  follows  $N^+(\mu, \sigma_u^2)$ , which is a truncated non-negative normal distribution of mean  $\mu$  and with standard deviation  $\sigma_u^2$ , that  $u_i$  takes a non-negative value; and  $T_i$  is set for each bank as the period the bank started appearing in our data. It is possible to

interpret this as when  $\mu$  is high the production of Cambodian commercial banks becomes inefficient on average. If  $\eta > 0$ , banks tend to improve cost efficiency in the observation period. If  $\eta < 0$ , banks are reducing their cost efficiency.

We examine whether economies of scale exist in Cambodian commercial bank by testing  $\partial \ln TC_{it} / \ln(Q_{1t}) + \partial \ln TC_{it} / \ln(Q_{2t}) = 1$ . We also test  $\partial^2 TC_{it} / \partial Q_{1t} \partial Q_{2t} = 0$  to examine the existence of the economies of scope.

### **3.2 Selection of Outputs and Inputs**

For the selection of outputs and inputs, we apply the value-added approach and the production approach following Grigorian and Mahole (2006). Although the intermediation approach is commonly also used in the literature, the value-added approach and production approach have some advantages in capturing the evolving nature of the banking business. Banks have been diversifying in recent years into fee and commission based service areas. In the value-added approach, stock variables, such as the size of loans and deposits, are used as output variables. Here, banks are supposed to improve their service provision ability in such areas as the financial intermediary function instead of simply maximizing revenue (Grigorian and Mahole 2006; Maudos and de Gueva 2007). This approach can take into account a bank's behavior in collecting deposits and settlement business through deposit accounts.

In the production approach, flow variables such as interest income and commission income, are used as output variables. Here, banks are supposed to try to maximize revenue by providing various kinds of financial services while managing their risks. The value-added approach has the problem of taking into account the quality of assets. Particularly, the difficulty in distinguishing between performing and non-performing assets could cause problems in the estimation. In the meantime, the production approach has the advantage of taking into account the

quality of loans. If banks have a lot of non-performing assets or invest mainly in low-profit earning assets, the production approach results in lower cost efficiency estimates.

Estimation results can vary across approaches. In this paper, we use both the value-added approach and the production approach and discuss Cambodian bank behavior from these two different points of view. The production approach that reflects the quality of assets directly is more suitable since the issue of asset quality is of serious concern in a liberated banking market. On the other hand, if the realities of the Cambodian economy and its undeveloped finance industry are taken into consideration, it is possible to think that expanding the mobility of domestic capital is an important function for banks. From this viewpoint, we discuss the characteristics and efficiency of banks with the help of the value-added approach in evaluating the amount of financial intermediation.

In this paper, we estimate bank cost efficiency using two different definitions of bank outputs. The first is the model that designates loan and deposit amounts as products on the basis of the value-added approach, and the second specifies the amount of interest income and non-interest income as products on the basis of the production approach.

### **3.3 Data set**

We obtain data from the Annual Supervisory Report published by the National Bank of Cambodia, which reports on the financial information of all the commercial banks in Cambodia on an annual basis. However, this data source lacks information on the personnel expenses of each commercial bank. We collect these missing data from the bank's audited financial statements. Using these data we construct an unbalanced panel dataset of 34 commercial banks for the four years between 2012 and 2015.

Table 1 shows the definitions of variables in detail. To avoid bias in estimation caused by outliers, we eliminated those banks that had been in business for less than one year. Some banks recorded a negative figure in non-interest revenue and so we also excluded these. The total number of bank observations over the study period is 131 banks in the case of the loan and deposit output measures and 127 banks in the case of interest and non-interest income products.

Table 1: Definitions of variables

### **3.4 Results of Estimation**

Table 2 shows the estimation results of formulas (1), (2), and (3) using the maximum-likelihood method. Model 1 applies the value-added approach in the choice of output variables, where outstanding loans and deposits are defined as outputs. Model 2 applies the production approach, where interest income and non-interest income are defined as outputs.

Table 2: Estimation by the trans-log type cost function

Regarding economies of scale, we find statistical significance in both Models 1 and 2. The results suggest that Cambodian commercial banks realize economies of scale in their operation. Our estimates of economies of scale are large compared to earlier single-country studies. For example, an estimate of scale economies for Malaysian banks has been found to be 0.851-0.950 (Okuda and Hashimoto 2004), that of Thai banks 0.861 for domestic banks and 0.676 for foreign banks (Okuda and Rungsomboon 2006), and for Vietnamese banks (returns to scale)

of 1.015 (Vu and Turnell 2010)<sup>3</sup>. However, it is noted that although our estimates are high this is likely a feature of the small number of banks in the sample and the relatively large size dispersion of Cambodian banks. Regarding the economies of scope, Model 1 shows insignificant results, meaning that these economies were not observed in the production of loans and deposits. Model 2 shows statistically significant results at 10%. This suggests that economies of scope exist between interest income from the production of loans and from other business in non-interest income like commission income.  $\eta$  is estimated positively although there is no statistical significance. It suggests that there was no significant trend on average in the changes of cost efficiency over the period in the Cambodian banking sector.

Next, we calculate the inefficiency scores  $IE_{it}$  to reveal how much cost inefficiency occurs in the Cambodian commercial banks:

$$TE_{it} = \frac{TC_{it}^*}{TC_{it}} = \exp\{C(\mathbf{Q}, \mathbf{w}) - C(\mathbf{Q}, \mathbf{w}) - u_{it}\} = \exp(-u_{it})$$

where:  $TE_{it}$  represents cost efficiency, and is measured by comparing actual cost level  $TC_{it}$  with ideal cost level  $TC_{it}^*$  in the case that inefficiency does not exist. We estimate  $TE_{it}$  as conditional expectation  $E\{\exp(-u_{it})|\epsilon_{it}\}$ <sup>4</sup>. As this value approaches close to 1 it shows that a bank's operation is cost-efficient. Table 3 shows the average cost efficiency of all the commercial banks, and also shows the difference in average cost efficiency between local and foreign banks. We define the banks where more than 50% paid-up capital is shared by foreign owners as foreign-owned banks. Otherwise, banks are defined as local banks.

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<sup>3</sup> Vu and Turnell (2010) calculated the return to scale as an inverse of scale economies.

<sup>4</sup> For the estimation of  $E(\exp(-u_{it})|\epsilon_{it})$ , see Baattese and Coelli (1992). We carried out the estimation with STATA command "xtfrontier."

Table 3: Averages cost efficiency by ownership structure

Cost efficiency in Cambodian commercial banks is relatively low. Model 1 and Model 2 share almost the same tendency. The average of the sample period is about 0.26 in Model 1 and about 0.29 in Model 2. In the case that banks are divided into foreign banks and local banks, the local banks show higher inefficiency in both Models 1 and 2, on average. These results indicate that Cambodian commercial banks could reduce their costs by around 71% to 74% and still produce the same outputs if they operated efficiently. The efficiency scores for Cambodian banks are relatively low even compared to estimated scores in the banking sectors of other developing countries. Bhattacharyya and Pal (2013) measured the efficiency of Indian banks between 1989 and 2009 by the estimation method proposed by Battese and Coelli (1992), and found an average bank efficiency of 0.630. In the case of Vietnamese banks, Vu and Turnell (2010) found that the average cost efficiency from 2000 to 2006 was 0.861-0.890 when they estimated the cost function using a Bayesian approach. For Latin American countries, Goddard et al. (2014) estimated bank efficiency scores ranging between 0.558-0.870 across different countries and estimation approaches.

#### **4. Determinants of Cost Inefficiency**

##### **4.1 Empirical Model**

In the previous section, we found that there was no significant trend in cost efficiency over the period. Given this result, in this section, we further examine the factors that affect the cost inefficiency of Cambodian commercial banks. To do so, we modify the distribution of inefficiency term in the cost function to be conditional on exogenous factors. Specifically,

following Battese and Coelli (1995), we redefine  $u_{it}$  that is the inefficiency terms of the formula (1) as follows:

$$u_{it} \sim N^+(\mu_{it}, \sigma_u^2) \quad (4)$$

$$\mu_{it} = \psi_0 + \psi_1 X_{it} \quad (5)$$

Where: Vector  $X_{it}$  represents the determinants of inefficiency. We estimate formula (1) with formulas (4) and (5) by the maximum-likelihood method. We examine the correlations between the mean of the distribution of inefficiency and the following variables chosen based on the literature about bank efficiency and the context of the Cambodian banking sector.

The first variable is liquidity ratio. Cambodian banks tend to have excessive liquidity ratios because of the dollarized economy and the unstable banking system. Because of the high liquidity risk, Cambodian banks are likely to keep high amounts of cash that could otherwise be used for lending. Here, we examine whether Cambodian banks maintain their liquidity without a loss in efficiency. Previous studies have also used the liquidity ratio to capture the risks from liquidity in bank operations (Brismis et al. 2008; Hou et al. 2013). In our study, we also capture liquidity in bank operations, using the liquidity ratios defined as cash holdings, deposits in the central bank, and total deposits in commercial banks as percentages of total assets.

The second factor is the level of business diversification. In addition to the revenue from traditional banking operations, such as loans and deposits, revenue from commission income has increased in the banking industry recently (Berger et al. 2010; Ghosh 2016). This is the case in Cambodia, and recently remittances and fee income from deposits have increased as the number of depositors has increased. Economies of scope are expected to be created by using the knowledge acquired in the course of undertaking different businesses in the banks. We use the

ratio of non-interest income to total revenue as a proxy for business diversification, and we estimate its influence on cost inefficiency.

The third factor is the ratio of deposits from foreigners to total deposits. Although previous studies have not focused on this variable, it is one of the distinctive features of the Cambodian banking sector. Figure 1 shows the ratio of deposits from foreigners to total deposits between 2012 and 2015. It lists banks in order of their asset value from largest to smallest. Many Cambodian commercial banks collect more than 40% of their deposits from foreigners, and some of them collect more than 80%.

Figure 1: Ratios of deposits from foreigners to total deposit

The fourth factor is the number of branches in rural areas. Illueca et al. (2009) found that branch expansion is positively associated with bank cost efficiency, while the degree of this relationship depends on how banks expand their branch networks.<sup>5</sup> In Cambodia, the profitability of banks in rural areas is thought to be low because their customers are mostly small- and medium-sized companies and the poor. Thus, it is natural to suppose that the denser the network in rural areas, the lower the cost efficiency. In our study, we presume that the ratio of branches in rural areas to total branches means the weight of business a bank puts in rural areas.

The fifth factor is how long a bank has been doing business. The longer it has been in business and the more customer information it accumulates, the more easily a bank can overcome asymmetry of information, and the easier it becomes to lend money to excellent customers.

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<sup>5</sup> The author found that if banks expand their branch networks in the areas where other banks also increase branches, productivity is not improved. If banks expand branches in the areas where other banks do not focus and wealthier people live, an improvement in their productivity was observed.

The sixth factor is the difference between foreign and local banks. Many previous studies discuss the difference between government-owned banks and private banks, as well as between foreign and local banks (Berger et al. 2005). However, in Cambodia all commercial banks are private companies, and the difference in cost efficiency due to ownership structure depends on whether a bank is foreign or local. Foreign banks that expand business to developing countries are in a better position to get hard information, but they are presumably in a disadvantageous position to get soft information and direct local management. Because foreign banks can more easily access the advanced technology of their home countries than local banks, foreign agencies from advanced countries have a competitive edge in terms of technology (Bonin et al. 2005). Although the literature presents mixed results in the effect of foreign ownership (Lenisnk 2008), foreign banks in developing countries tend to show higher efficiency than local entities (Grigorian and Manole 2002; Bonin 2005; Havrychuk 2006; Silva et al. 2016). In the model, we define banks in which foreign capital accounts for more than 50% of total capital as a foreign bank and other banks as a local bank and use a dummy variable 1 if the bank is a foreign bank.

#### **4.2 Results of Estimation**

Table 4 shows the results of estimations conducted by the maximum-likelihood method using formulas (1), (4), and (5). The table includes estimation results of determinants of items for inefficiency besides those conducted by the frontier function. At the same time, it also shows the marginal effect figured out on the basis of the average of each variable to estimate the economic impact from the inefficiency result of each variable.<sup>6</sup>

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<sup>6</sup> We used the method explained in Kumbhakar et al. (2015) to estimate the marginal effect in the model of Battese and Coelli (2012).

Table 4: Estimation of determinants of inefficiency

Several explanatory variables as determinants of cost inefficiency were found to be significant in Model 1, but no variables were significant in Model 2. This may indicate that the determinants of the factors of cost efficiency in terms of quantity are different from those of cost efficiency in terms of quality. First, liquidity ratios correlate with inefficiency in a positive direction significantly in Model 1. That is, banks with excessive liquidity are inefficient in the production of loans and deposits. The marginal effect is 0.686, and it shows that inefficiency increases by about 11% ( $=0.686*0.16*100$ ) per change in the standard deviation of liquidity of a bank, indicating that liquidity ratio greatly affects cost inefficiency. The finding is different from Ghosh (2016), who found no significant correlation between liquidity ratios and bank profits.

In this study it was found that business diversification is negatively associated with inefficiency. Or put another way, diversification boosts efficiency. This result is also consistent with previous studies, such as Berger et al. (2010) and Ghosh (2016). Furthermore, in our results the marginal effect was -1.404, and means about a 18% change for every change in standard deviation, indicating that it has the largest impact on inefficiency among our explanatory variables.

The ratio of branches in local areas to the total number of branches positively correlates with inefficiency. This indicates that expanding a branch network into local areas is inefficient for bank management. In addition, economic impact shows a 12% increase in inefficiency for every change in standard deviation, indicating that it also has a major effect. This result is in contrast to that of Thilakaweera et al (2016), who investigated the changes in efficiency before/after conflict. They found that bank efficiency increased after the conflict as branch networks expanded. Our

results may suggest that the creation of branches is not always associated with the profit-seeking motive, and that branch expansion can be costly in the case of Cambodia.

The ratio of deposits from foreigners is not significant even though it shows a positive correlation with inefficiency, contradicting our expectations. However, this is possibly not because procuring capital from abroad is efficient but because those banks that cannot procure deposits efficiently inside the country are conducting a financial intermediary business to procure capital from abroad.

## **5. Conclusion**

This study investigates the efficiency of Cambodian commercial banks, which have been growing steadily since the 2000s. Specifically, we measure the cost efficiency of 34 commercial banks during the period from 2012 to 2015 using stochastic frontier analysis of data from the National Bank of Cambodia and individual bank financial statements. Our results are summarized below.

Economies of scale are realized in the Cambodian banking industry and this was found using two different output set-ups. In addition, we find evidence of scope economies when we define outputs as combining interest and non-interest income. We also observe a great deal of inefficiency in Cambodian commercial banking – on average banks are around 71-74% inefficient. By estimating the determinants of the cost efficiency of Cambodian commercial banks, we find that excessive liquidity negatively affects efficiency, and that diversification of bank business is effective in increasing cost efficiency. Nevertheless, expanding a branch network into local areas is associated with greater inefficiency. Lastly, we find that the amount of non-resident deposits is not associated with bank cost efficiency.

From these results we can draw several policy implications for the further improvement of bank efficiency. First, it is necessary to expand the scale of a bank and develop diversification

because Cambodian banks can realize both scale and scope economies. Second, expanding a branch network into local areas reduces bank efficiency. So, any such expansion should be gauged appropriately by management. Supportive measures are required for the expansion of branches from the viewpoint of facilitating the mobility of domestic capital. Third, excessive liquidity owned by banks is a cause of inefficiency, and it is strongly suggested that Cambodia takes measures to recover the function of the central bank as the lender of last resort in its dollarized economy.

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**Table 1: Definitions of variables**

Variables		Definition
<i>Costs</i>		
Total cost	$TC_{it}$	Interest expenses + depreciation + personnel expenses (adusted by CPI)
<i>Output</i>		
Loans	$Q_{1,it}$	Outstanding loans (adusted by CPI)
Deposits	$Q_{2,it}$	Total customer deposits (adusted by CPI)
Interest income	$Q_{3,it}$	Interest income (adusted by CPI)
Non-interest income	$Q_{4,it}$	Non-interest income (adusted by CPI)
<i>Input</i>		
Interest price	$w_{1,it}$	Interest expenses / total debts
Capital price	$w_{2,it}$	depreciation and amortization/Fixed Assets
Labor price	$w_{3,it}$	perssonel/number of staff (adusted by CPI)

**Table 2:** Estimation by the trans-log type cost function

	Model1		Model2
Output	(1) Loans (2) Deposits		(1) Interest income (2) Non-interest income
Input Prices	(1) Interest rate (2) Capital price (3) Labor price		(1) Interest rate (2) Capital price (3) Labor price
Dependent variable: Log. Total Cost			
$\ln(Q_{1,it})$	0.215 (1.03)	$\ln(Q_{3,it})$	0.528*** (2.98)
$\ln(Q_{2,it})$	0.194 (1.17)	$\ln(Q_{4,it})$	0.089 (0.52)
$\ln(w_{1,it}/w_{2,it})$	0.580*** (6.77)	$\ln(w_{1,it}/w_{2,it})$	0.488*** (6.08)
$\ln(w_{3,it}/w_{2,it})$	0.440*** (5.06)	$\ln(w_{3,it}/w_{2,it})$	0.512*** (6.10)
$\ln(w_{1,it}/w_{2,it}) \ln(w_{1,it}/w_{2,it})$	0.004 (0.20)	$\frac{1}{2} \ln(w_{1,it}/w_{2,it}) \ln(w_{1,it}/w_{2,it})$	0.017 (0.91)
$\frac{1}{2} \ln(w_{3,it}/w_{2,it}) \ln(w_{3,it}/w_{2,it})$	0.003 (0.26)	$\frac{1}{2} \ln(w_{3,it}/w_{2,it}) \ln(w_{3,it}/w_{2,it})$	0.018** (2.04)
$\frac{1}{2} \ln(Q_{1,it}) \ln(Q_{1,it})$	0.075 (0.94)	$\frac{1}{2} \ln(Q_{3,it}) \ln(Q_{3,it})$	0.041 (0.61)
$\frac{1}{2} \ln(Q_{2,it}) \ln(Q_{2,it})$	0.103 (1.51)	$\frac{1}{2} \ln(Q_{4,it}) \ln(Q_{4,it})$	0.051 (0.84)
$\ln(w_{1,it}/w_{2,it}) \ln(w_{3,it}/w_{2,it})$	-0.014 (-0.96)	$\ln(w_{1,it}/w_{2,it}) \ln(w_{3,it}/w_{2,it})$	-0.051*** (-3.83)
$\ln(Q_{1,it}) \ln(Q_{2,it})$	-0.169 (-1.16)	$\ln(Q_{3,it}) \ln(Q_{4,it})$	-0.076 (-0.61)
year2013 (Dummy)	-0.034 (-0.54)	year2013 (Dummy)	-0.007 (-0.12)
year2014 (Dummy)	-0.041 (-0.36)	year2014 (Dummy)	-0.006 (-0.07)
year2015 (Dummy)	-0.122 (-0.28)	year2015 (Dummy)	1.681*** (4.03)
Constant	2.920*** (2.88)	Constant	0.804 (1.05)
$\mu$	1.550*** (3.39)	$\mu$	1.396*** (4.24)
$\eta$	-0.037 (-1.03)	$\eta$	-0.012 (-0.40)
Observations	131	Observations	127
Economies of Scale	.513		.739
Wald test	50.70		11.41
P-Value	0.000		0.001
Economies of Scope	3.718e-09		5.425e-06
Wald test	1.78		2.82
P-Value	0.1816		0.093

Note: \*, \*\*, and \*\*\* represent statistical significance at 10%, 5%, and 1%, respectively. Model 1 applies the value-added approach in the choice of output and input variables, and Model 2 applies the production approach. We estimated Model 1 and Model 2 with Battese and Coelli's (1992) specification of the frontier function.

**Table 3: Averages of cost efficiency scores by ownership structure**

Year	All Banks				Domestic Banks				Foreign Banks			
	Model 1		Model2		Model 1		Model2		Model 1		Model2	
	TE	No. of Banks	TE	No. of Banks	TE	No. of Banks	TE	No. of Banks	TE	No. of Banks	TE	No. of Banks
2012	0.29	31	0.30	31	0.32	15	0.33	15	0.26	16	0.28	16
2013	0.27	32	0.30	31	0.30	16	0.32	15	0.25	16	0.28	16
2014	0.24	34	0.28	32	0.24	17	0.29	15	0.23	17	0.27	17
2015	0.23	34	0.28	33	0.23	17	0.29	16	0.22	17	0.27	17
Total	0.26	131	0.29	127	0.27	65	0.31	61	0.24	66	0.27	66

**Table 4:** Estimation of determinants of inefficiency

	Model1		Model2	
Output	(1) Loans (2) Deposits		(1) Interest income (2) Non-interest income	
Input Prices	(1) Interest rate (2) Capital price (3) Labor price		(1) Interest rate (2) Capital price (3) Labor price	
Dependent variable: Log. Total Cost				
$\ln(Q_{1,it})$	-0.081 (-0.31)	$\ln(Q_{3,it})$	0.623*** (3.53)	
$\ln(Q_{2,it})$	0.609*** (3.58)	$\ln(Q_{4,it})$	0.288** (1.97)	
$\ln(w_{1,it}/w_{2,it})$	0.836*** (8.81)	$\ln(w_{1,it}/w_{2,it})$	0.738*** (7.05)	
$\ln(w_{3,it}/w_{2,it})$	0.070 (0.70)	$\ln(w_{3,it}/w_{2,it})$	0.148 (1.42)	
$\frac{1}{2}\ln(w_{1,it}/w_{2,it})\ln(w_{1,it}/w_{2,it})$	0.017 (0.84)	$\frac{1}{2}\ln(w_{1,it}/w_{2,it})\ln(w_{1,it}/w_{2,it})$	-0.024 (-1.30)	
$\frac{1}{2}\ln(w_{3,it}/w_{2,it})\ln(w_{3,it}/w_{2,it})$	0.021 (1.41)	$\frac{1}{2}\ln(w_{3,it}/w_{2,it})\ln(w_{3,it}/w_{2,it})$	0.034** (2.39)	
$\frac{1}{2}\ln(Q_{1,it})\ln(Q_{1,it})$	0.256*** (3.65)	$\frac{1}{2}\ln(Q_{3,it})\ln(Q_{3,it})$	0.099* (1.88)	
$\frac{1}{2}\ln(Q_{2,it})\ln(Q_{2,it})$	0.233*** (4.01)	$\frac{1}{2}\ln(Q_{4,it})\ln(Q_{4,it})$	0.129*** (2.60)	
$\ln(w_{1,it}/w_{2,it})\ln(w_{3,it}/w_{2,it})$	-0.044** (-1.98)	$\ln(w_{1,it}/w_{2,it})\ln(w_{3,it}/w_{2,it})$	-0.037*** (-2.82)	
$\ln(Q_{1,it})\ln(Q_{2,it})$	-0.465*** (-3.76)	$\ln(Q_{3,it})\ln(Q_{4,it})$	-0.107** (-2.18)	
year2013 (Dummy)	-0.023 (-0.38)		0.008 (0.13)	
year2014 (Dummy)	-0.035 (-0.56)		-0.010 (-0.15)	
year2015 (Dummy)	-0.079 (-0.39)		1.587*** (6.13)	
Constant	3.647*** (3.84)		1.618* (1.96)	
Observations	131		127	

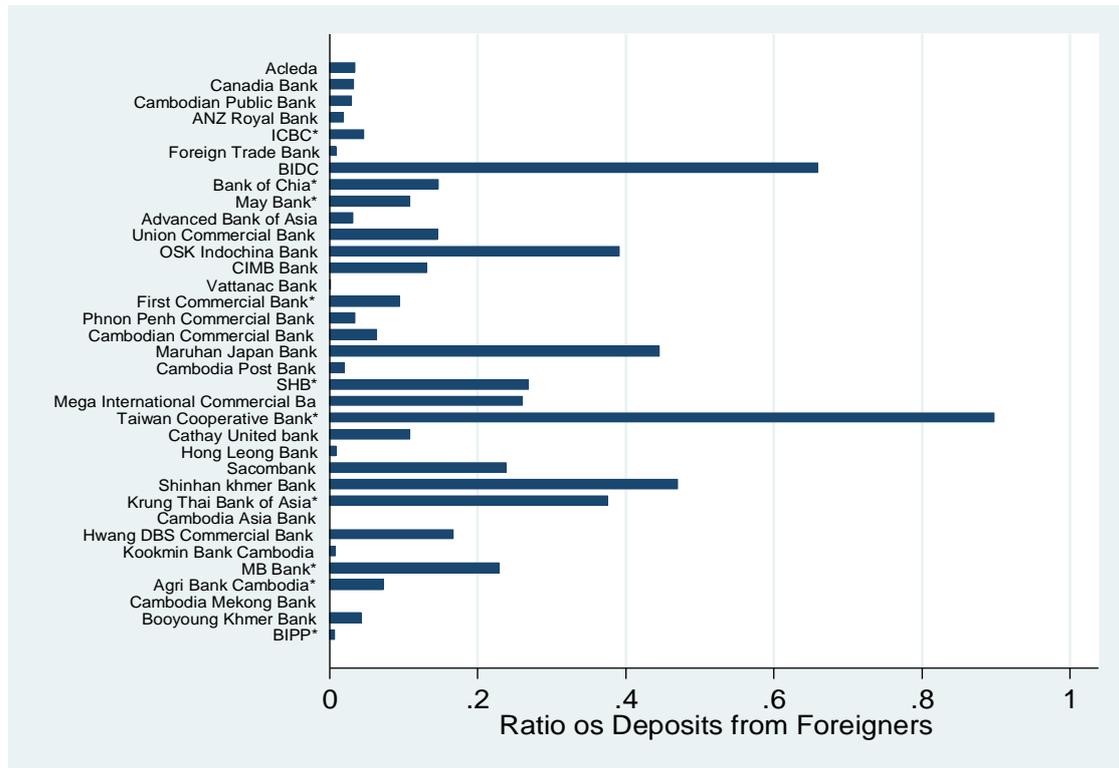
Note: \*, \*\*, and \*\*\* represent statistical significance at 10%, 5%, and 1%, respectively. Model 1 applies the value-added approach in the choice of output and input variables, and Model 2 applies the production approach. We estimated Model 1 and Model 2 with Battese and Coelli's (1992) specification of the frontier function.

**Table 4:** Estimation of determinants of inefficiency (cont)

Inefficiency	Model1	Marginal Effect	Inefficiency	Model2	Marginal Effect
Liquidity ratio	3.648** (2.03)	0.687	Liquidity ratio	2.703 (1.49)	.754
foreignn_deposits_ratio	0.902 (1.43)	0.170	foreignn_deposits_ratio	0.282 (0.51)	.079
diversification	-7.455* (-1.85)	-1.404	diversification	0.195 (0.13)	.054
rural_ratio	2.312* (1.95)	0.435	rural_ratio	1.313 (1.51)	.366
Operation period	-0.023 (-0.90)	0.004	Operation period	-0.033 (-0.98)	-.009
foreign_dummy	-0.014 (-0.05)	-0.003	foreign_dummy	-0.096 (-0.40)	-.027
Constant	-1.805 (-1.36)		Constant	-1.606 (-0.89)	

*Note:* \*, \*\*, and \*\*\* represent statistical significance at 10%, 5%, and 1%, respectively. Model 1 applies the value-added approach in the choice of output and input variables, and Model 2 applies the production approach. We estimated Model 1 and Model 2 with Battese and Coelli's (1992) specification of the frontier function.

**Figure 1: Ratios of deposits from foreigners to total deposit**

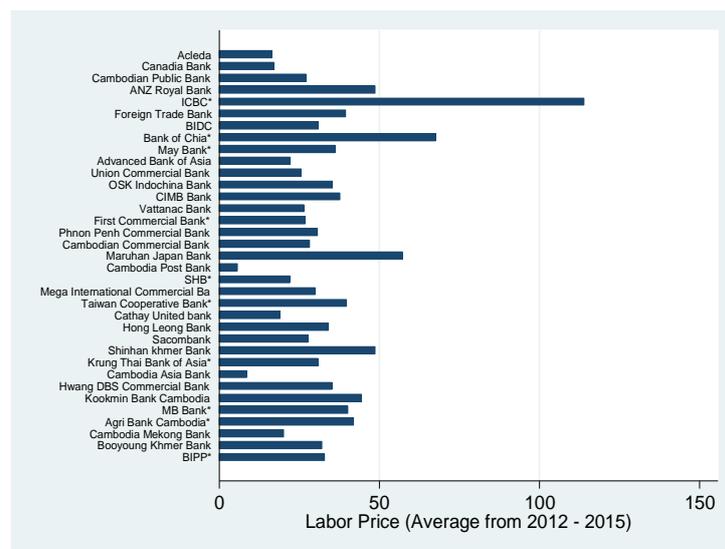
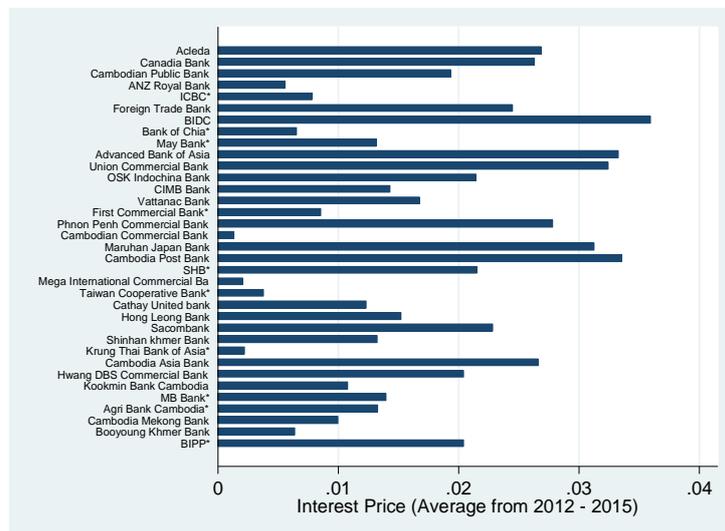
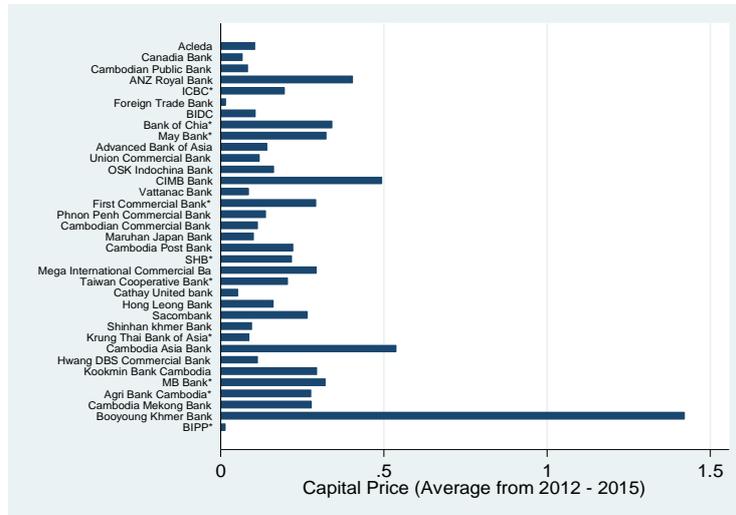


Source: Data provided by National Bank of Cambodia and Author calculations.

### Appendix 1: Descriptive statistics

	number of sample	average	standard deviation	minimum	maximum
Total cost	131	381167.20	943289.50	5.36	5646369.00
Loans outstanding	133	583893.90	1080891.00	245.82	6962175.00
Deposits outstanding	133	640846.50	1267337.00	21.77	6790571.00
Interest income	133	57165.26	135262.40	24.39	920160.20
Non-interest income	133	10653.90	20382.64	-1645.13	114153.30
Average interest rate	133	0.02	0.01	0.00	0.05
Average rental cost	133	0.23	0.30	0.00	2.75
Average wage	133	34.73	30.06	0.14	162.74
Liquidity ratio	131	0.43	0.16	0.07	0.98
Deposits from abroad	133	0.15	0.21	0.00	0.90
Operation diversification index	133	0.18	0.13	-0.07	0.64
Ratio of rural branches	133	0.28	0.27	0.00	0.94
Years of operation	133	10.44	8.45	1.00	36.00
Dummy for foreign ownership	133	0.50	0.50	0.00	1.00

## Appendix 2: Factor prices by bank



Source: Data provided by National Bank of Cambodia and Author calculations.

## Abstract (in Japanese)

### 要約

カンボジアの銀行セクターはここ数十年の間に経済の成長とともに急激に大きく拡大している。しかし、カンボジアの銀行セクターでは、いくつかの不安要素が指摘されている。そして、定量的な研究が少ないため問題に対する有効な政策がとりづらいことも問題の一つである。本研究では、カンボジアでの銀行の費用関数を推定することによって、銀行行動に関しての定量的なエビデンスを提供する。本研究では、2012年から2015年間の34行の商業銀行のデータを用いた。本研究では、カンボジアの商業銀行の経営効率性スコアが平均して0.26–0.29と推定された。これは、カンボジアの商業銀行は平均して76%–79%のコストが現在のアウトプットを維持したまま削減できることを意味する。また、カンボジアの商業銀行では規模の経済性が存在することが観測された。さらに、非効率性の要因分析を行ったところ、地方へ支店の拡大と非効率性が相関していたこと、高く流動性を維持する銀行ほど非効率性が高いこと、そして銀行経営が多様化するほど非効率性の低下が見られる傾向があることがわかった。

**キーワード:** カンボジア、費用関数の推定、効率性、銀行行動、確率的フロンティア分析