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Early Warning of Banks Failure in Cambodia: Cox's Proportional Hazard Model

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ABSTRACT

This study uses CAMEL rating method which consists of five variables with the Cox's Proportional Hazard model to predict the probability of survivor or stability rate of banks in Cambodia. The result indicates that capital adequacy and liquidity of the banks are the two main indicators explained the stability or survivor rate of banks. The predicted result of the Kaplan Meier Survivor shows that the stability of banking system in Cambodia is high in the short-run, but the instability of the financial system might occur in the long-run since the banks survivor rate is rather low. The result of survey reveals that about one third of the compliance based bankers has ever learned about CAMEL and only a few banks employ some methods or techniques in predicting the stability or survivor rate of the bank, while the early warning system of bank failure for the whole banking system does not really exist yet.

Keywords: CAMEL, Cox's Proportional Hazard, Kaplan Meier, Survey.

INTRODUCTION

In the last four or five years, Cambodia could maintain economic growth rate on average 7 percent per year. The sources of growth are derived from three sectors: services mainly tourist, industry, and agriculture. As of 2017, 42.31 percent, 32.73 percent and 24.96 percent of domestic outputs come from services, industry and agriculture, respectively, (ADB, 2018). The annual average unemployment rate is rather low of no more than 0.3 percent, from 2013 to 2017, (WB, 2018). At the same time, the gross fixed capital investment increase by about 14.5 percent per year, thanks to the economic growth, (ADB, 2018).

Of course, these growths could not be accomplished without the source of funds which provided by financial institutions definitely in Cambodia none of any institutions would do beside banks. As of December 2017, the total numbers of commercial banks in Cambodia are 39 with the average growth rate of three banks per year, between 2009 and 2017. Between 2013 and 2017, the annual banks' credit growth rate for private sector is approximately 25 percent, (NBC, 2017). Despite the Cambodia Securities Exchange (CSX) has been officially established since April 2012 as another channel for searching financial resources, but the raise of funds by local and foreign firms for domestic investment is still not that popular yet in this financial market as compare to banks. Currently, the total numbers of public listed companies in CSX are five (CSX, 2018). Because the financial systems in Cambodia are dominated by banks which play a very crucial role in providing loans to the one who have shortage of funds and accepting deposits from those who have excess of funds.

To maintain a sustainable economic growth and development in the long-run, Cambodia needs a sound and safe banking system in order to guarantee the availability of credits for domestic investment. In contrast, banks failure would lead to a catastrophic collapsed of the economy in the country as a whole. To assess the performance and risk of individual bank as well as of the whole banking system, CAMELS rating method which is one of the most popular method or technique is generally be applied by banks as well as regulators. Six indicators are included in this rating technique which is Capital adequacy (C), Asset quality (A), Management (M), Earnings (E), Liquidity (L) and Sensitivity to market risk (S).

Besides using CAMELS rating method to evaluate the performance and risk of banking system, the prediction of survivor or stability rate of banks should also be carried out by using some econometric models. The predicted result of the survivor or stability rate of banks could have been used by the central bank or others related institutions as an early warning model of banks failure in order to find

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proper policies to cope with banks crisis that might have occurred in the future. One of the most famous models that always been used to predict the banks failure is the Cox's Proportional Hazard model. The main purposes of this study are,

1. To predict the survivor or stability rate of commercial banks in Cambodia by applying the Cox's Proportional Hazard model with CAMELS rating technique,
2. To determine which component of CAMELS explain the survivor or stability rate of commercial banks in Cambodia the most,
3. To observe which techniques or methods that bank uses to measure bank's survivor rate, bank's performance and bank's risk,
4. To provide suggestion or policy implication to the central bank regarding to the creating or using of the early warning model as such Cox's Proportional Hazard model in Cambodia's banking system.

In calculating each item of CAMELS, which will be explained in detail in the research methodology part, to be used to run in the Cox's Proportional Hazard model, this research can collect and use only annually data from 2013 to 2017 since the high frequency data such as monthly, quarterly or semi-annually are not available.

LITERATURE REVIEW

Cox's Proportional Hazard model used to be employed in the U.S.'s banking industry as a particular early warning system of bank failure within 1980s and 1990s since "[t]he number of U.S. bank failure jumped sharply in the mid-1980s and has remained disturbingly high, averaging roughly 170 banks a year over the 1985-1990 period." Monthly data is applied between January 1, 1987 and October 31, 1990 which has taken into account all banks that failed. Six explanatory variables are included in the model: LAR (Total loans/total assets), OHR (Operating expenses/ average total assets), ROA (Consolidated net income/ average total assets), CD100R (Total domestic time deposits in denominations of $100,000 or more/total assets), PCR (Primary capital/average total assets), NPCR (PCR less (total nonperforming loans/average total assets) and PCHP64 (Percent change in state's residential housing permits measured over the 198x to 198y period). As refer to the estimated result all of the independent variables are highly statistically significant explain banks failure. In addition, this study has also found that the survival probability of healthy bank is higher than unhealthy as well as critically ill bank for the period of 24 months prediction (Whalen, 1991).

Annually data of public listed and private banks in nine Central and East Asia countries, from 2000 to 2009, have been incorporated in the Cox's Proportional Hazard as well as the Probit models. The result of the study has indicated that banks' derivative and credit risk indicators explained the prediction of banks failure better than banks' business structure variables and off-balance sheet items (Malick Sy, 2011).

Another paper is applied similar research method as of Whale, but in the Nigeria's banking industry over a sample period cover from 2003 to 2011, annually data. Two main indicators, asset quality variable which equal to non-performing loan (NPL) divided by total loan and management variable which equal to operating expense divided by average total assets, highly explain the probability of bank failure in Nigeria (Babajide Abiola A., 2013).

METHODOLOGY

Model and Data

A parametric model is written as,

$$log h_i(t, x, \beta) = \alpha(t) + \sum_{j=1}^{k} \beta_j x_j \qquad (1)$$

when all independent variables, x, equal to zero, the model is reduced to

$$log h_i(t, x, \beta) = \alpha(t) \qquad (2)$$

take exponential on both sides of equation (2), to get

$$h_i(t) = e^{\alpha(t)} \qquad (3)$$

which is regarded as base line log hazard.

Take exponential of (1), the following equation is derived:

$$h_i(t, x, \beta) = exp\left(\alpha(t) + \sum_{j=1}^{k} \beta_j x_j\right) \qquad (4)$$

Equation (4) can be simplified as

$$h_i(t, x, \beta) = e^{\alpha(t)} e^{\sum_{j=1}^{k} \beta_j x_j} \qquad (5)$$

Since the base line hazard function, h_0 (t)=e^α(t) , is

not specified by the Cox's model, a semi-parametric model is derived as below

$$h_i(t,x,\beta) = h_0(t)e^{\sum_{j=1}^{k}\beta_j x_j} \quad (6)$$

Let denote a function, $r(x,\beta) = e^{\sum_{j=1}^{k}\beta_j x_j}$, thus

$$h_i(t,x,\beta) = h_0(t)r(x,\beta) \quad (7)$$

Let consider two different value of x, x_0 and x_1,

$$h(t,x_1,\beta) = h_0(t)r(x_1,\beta) \quad (8)$$

$$h(t,x_0,\beta) = h_0(t)r(x_0,\beta) \quad (9)$$

The Hazard Ratio (HR) is

$$HR(t,x_0,x_1) = \frac{h(t,x_1,\beta)}{h(t,x_0,\beta)} = \frac{h_0(t)r(x_1,\beta)}{h_0(t)r(x_0,\beta)} = \frac{r(x_1,\beta)}{r(x_0,\beta)} \quad (10)$$

which is depending only on function r(x,β). This model is known as the Proportional Hazard model (Cox D. R., 1984).

As refer to (Cox D. R., 1972), a survivor function is written as

$$S(t,x,\beta) = [S_0(t)]^{e^{\sum_{j=1}^{k}\beta_j x_j}} \quad (11)$$

Maximum Likelihood Estimation (MLE) method is applied to estimate the parameters of the Cox's Proportional Hazard model and the log-likelihood function (LLF) is written as below,

$$LLF = \sum_{i=1}^{n}\left\{d_i X_i\beta - ln\left[\sum_{k\in R_{(i)}} exp(X_k\beta)\right]\right\}X \quad (12)$$

where,

Xs : are independent variables,

βs : are slope coefficients of independent variables,

d_i : is a dummy variable which represent the size of the banks,

1 = Large bank

0 = Small bank

The average of each bank's asset greater than or equal to 4 percent of the average of total banks' assets in the industry will be classified as a large bank.

The independent variables are known as CAMEL which are specified as follow,

C : Capital Adequacy = Capital/Total Assets,

A : Asset Quality = Non Performing Loan/Loans,

M : Management = Operating Expense/Total Assets,

E : Earnings = Net Profit/Total Assets,

L : Liquidity = Liquidity Assets/Deposits,

The sample parameters, $\hat{\beta}$, are selected to maximize the log-likelihood function. After, all slope coefficients are found; the test of Proportional Hazard assumption is conducted to check whether the Hazard Ratio is constant over time or not.

$$HR(t,x_0,x_1) = \frac{r(x_1,\beta)}{r(x_0,\beta)} = \hat{\theta} \quad (13)$$

In this study, the unstable bank is referred to a bank which has been taken over by the other bank, or merged with the other bank, or generated net loss in the last one or two year (Apinya, 2004).

Before running MLE, Spearman rank correlation test is conducted to find the correlation between all independent variables. The formulation of the Spearman rank correlation coefficient, r_s, is (Anderson, 2015)

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)} \quad (14)$$

where

n = the number of items being ranks,

x_i = the rank of item i with respect to first variable,

y_i = the rank of item i with respect to second variable,

$d_i = x_i - y_i$

The period of the study is cover from 2013 to 2017. Annually data is employed. As of 2017, totally, 39 commercial banks are running business in Cambodia. This study focus only on commercial banks, specialized banks is excluded. All data are collected from the National Bank of Cambodia's Annual Supervision Report and on respected bank's report.

Research Design

To get into detail into the techniques or methods that commercial banks are currently used in measuring bank's performance as well as risk and to learn about some models that might have been applied by banks in predicting bank's survivor or stability rate in the

next few years in the future, this study also conducting a survey to all of the commercial banks in Cambodia. The questionnaire is developed which consists of ten items (see Appendix). The questionnaire is classified into three main parts as indicated in Table I.

Table I Objective of Each Group Items of the Questionnaire

Sections	Objectives	Item Number
1	Demography of respondent and bank	Item 1 to Item 4
2	Bank's techniques or methods in assessing bank's performance and risk	Item 5 to Item 7
3	Willingness to learn about techniques or methods in assessing bank's performance and risk	Item 8 to Item 10

After the questionnaire has been established, five experts who work in related field from different banks are invited to fill the developed questionnaire. The problems or questions that might have happened during the filling process of the five experts related to the questionnaire will be recorded and used to improve the questionnaire. The questionnaire will be sent to all of commercial banks running the business in Cambodia as refer to the contact address provided by the central bank. The collection of the survey data is conducted between November and December of 2018. To check the reliability of research instrument, Cronbach's alpha is applied.

RESEARCH RESULT

This section is divided into two main parts, the interpretation of the empirical result of the Cox's Proportional Hazard model is presented in the first part and the survey result is explained in the second part.

Table II Spearman Rank Correlation Coefficient

Variables	C	A	M	E	L
C	1				
A	0.1839	1			
M	0.4354	0.1277	1		
E	-0.4753	-0.5335	-0.5281	1	
L	0.4955	-0.0078	-0.1593	0.1331	1

As revealed in Table II, all independent variables are not highly correlated. The Earning variable has negative relationship with Asset Quality and Management of 0.5335 and 0.5281, respectively, beside that all of the correlation between the independent variables are less than 0.5 which are regarded as low.

Table III Estimated Parameters of the Cox's Proportional Hazard Model

	Model 1	Model 2
	Coefficient	Coefficient
Variables	(Robust Std. Err.)	(Robust Std. Err.)
C	9.214313*	8.901301*
	(3.0299)	(3.1479)
A	-3.0383	-2.0614
	(24.4492)	(24.8658)
M	-7.2713	-7.3481
	(19.7163)	(19.4727)
E	-127.5648	-123.7281
	(85.2966)	(87.3230)
L	-1.8784*	-1.8479*
	(0.6164)	(0.6124)
SIZE		-40.9088
		(N/A)
Log likelihood	-7.1614	-7.1244
Global test (df)	0.9092	0.9114

* Significant at 1% level.

Two models are run in this research, Model 1 and Model 2. Model 1 is employed all CAMEL indicators, but excluded banks size which is a dummy variable, 1=Large bank and 0=Small bank, while Model 2 is included banks size with CAMEL variables. Of course, during the period of the study, 39 commercial banks are running the business in Cambodia, but only 35 banks have enough data set. The result of this study has indicated that among the 35 banks, 7 banks are classified as large bank since each of those banks has an average total asset greater or equal to 4 percent of the average total asset of all banks in the industry, between 2013 and 2017.

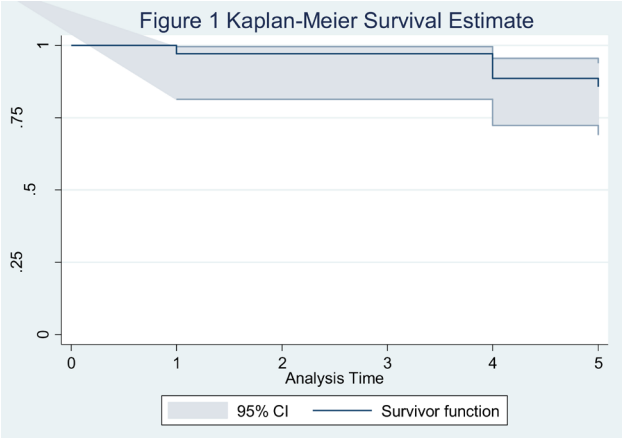
As indicated in Table III of Model 2, an error is generated when banks size is included with CAMEL independent variables since the robust standard error of banks size is not available (N/A). Thus, the estimated result of Model 1 is selected by not including the banks size in the model. Before interpreting Model 1, the test of the Proportional Hazard assumption is performed and the result is shown in Table IV.

Table IV Test of the Proportional Hazard Assumption

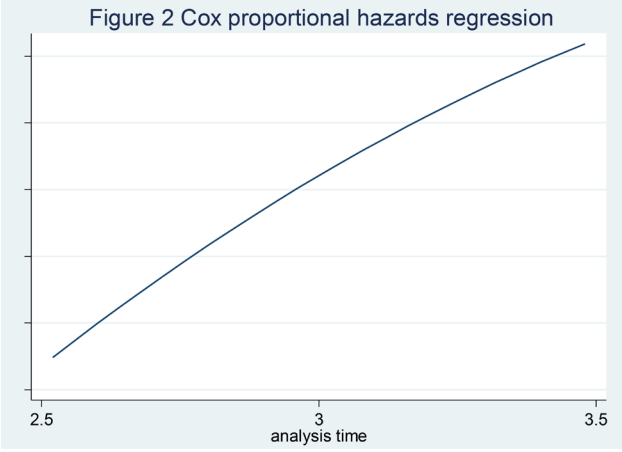
	rho	chi2	Df	Prob>chi2
C	0.18530	0.62	1	0.4325
A	-0.23046	1.19	1	0.2757
M	-0.32313	0.31	1	0.5785
E	-0.21609	1.09	1	0.2969
L	0.34442	0.34	1	0.5583
Global test		1.53	5	0.9092

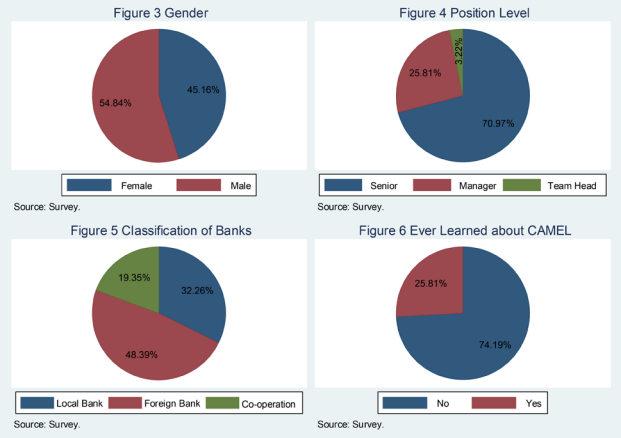
The probability of Chi-square of the Global test is 0.9092 which is greater than 5 percent significant level which can be concluded that the null hypothesis that the Hazard Ratio (HR) is not vary with time is

failed to reject. This model is fulfilled the assumption of the Cox's Proportional Hazard model. Among the five independent variables of CAMEL, only two variables are statistically significant at 1 percent level explained the stability of banking system in Cambodia which are capital adequacy and liquidity variables. The sign of the capital adequacy's coefficient is positive, 9.214313, which support the stability of banking system, while the coefficient of liquidity is negative, -1.8784, which damage banks' strength. Using all of the coefficients, the survivor rates of banks are made for the period of five years (see Figure 1).



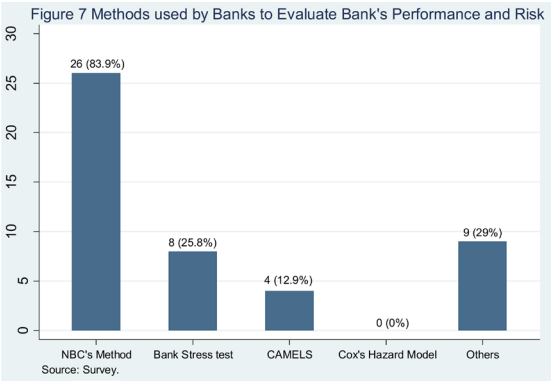
The survivor or stability rate of banking system in Cambodia is high in the first year, but has slightly declined from the beginning of the second year to the end of the third year and has a moderate decreased from the beginning of the fourth year onward since within 95 percent confident interval (CI), the probability of banks stability or survivor rate in the lower bound is approximately 68 percent. This prediction has shown that in the long-run, the stability of the banking system in Cambodia keep declining every year which provide an early warning signal that the instability of the financial system might have occurred in the future. In addition, the Cox Proportional Regression line is smooth with positive slope and rapidly increases when analysis time goes forward, as indicated in Figure 2.





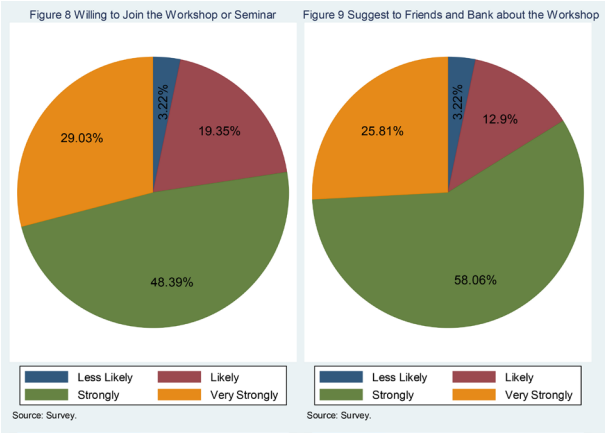
As explained earlier, this research use both econometric model, Cox's Proportional Hazard model, and survey. Before interpreting the surveyed data, the test of validity of research instrument using Cronbach's alpha is conducted. The value of the Cronbach's alpha is 0.6995 which can be concluded that research instrument is reliable.

During the survey period, between November and December of 2018, 31 commercial banks gave feedback to the send questionnaire. Most of the banks are foreign banks which accounted for 48.39 percent. Moreover, 54.84 percent who answered to the assigned questionnaire are male. Among the respondents, 70.97 percent, 25.81 percent, and 3.22 percent are position as senior, manager and team head in the bank, respectively. Surprisingly, only 25.81 percent of the respondents have ever learnen about CAMEL, while 74.19 percent have never learned.



To evaluate bank's performance as well as risk, 83.9 percent complied with the National Bank of Cambodia's method. About 12.9 percent or 4 banks currently use CAMELS, 25.8 percent or 8 banks use Bank Stress test, and approximately 29 percent or 9 banks use others evaluation methods or techniques in assessing bank's perfomance and risk, while all of the banks have never used Cox's Proportional Hazard model.

Neverthless, most of the respondents are strongly willing to join and share information related to seminar or workshop which give a chance for the respondents to learned about CAMELS, Bank Stress test, and Cox's Proportional Hazard model.



CONCLUSION

The result of this study has indicated that the banks' survivor or stability rate is highly explained by two main variables of CAMEL which are banks' capital adequacy and banks' liquidity. The increase in banks' capital adequacy would help strengthening the stability of banking system since the slope coefficient of the variable is found to be positively significant, while the increase in banks' liquidity would damage banks' stability rate due to a negative slope coefficient is found in the estimated result, despite of the level of significant is high of 1 percent level. The Kaplan Meier Survivor estimation has predicted that in the long-run, Cambodia might face with the instability of the financial system since the predicted survivor rate is low at about 68 percent regarding to the lower bound of the 95 percent CI.

To guarantee a sound and safe banking system, of course, capital adequacy is the most important indicator which has to be maintained in a proper manner in value by all banks. The central bank plays a very crucial role in setting capital requirement as well as assessing the availability of capital of all banks in the industry; thus, the processes of compliance based regulation, on-site and off-site supervision, which are carried out by central bank's professional expertise have to be strictly performed.

Each bank tries to hold a lot of liquidities on hand to prevent an immediate withdraw of cash by bank's customers on the deposited accounts which can lead to bank run, if bank does not have enough cash or liquidities. In contrast, holding a large amount of liquidities would cause bank losing an opportunity in generating interest revenues as well as profits since bank could have made loans of the excessed liquidities to the public. Most part of bank's liquidities is generated from bank's deposit accounts which are not cost free. If a routinely activity of all banks in the system related to the holding of huge amount of liquidities still being like this; day by day, in the long-run, would have a negative impact on bank's profit and bank's capital and this process might trigger banks failure.

The present of the interbank market would have helped banks partly solving the above issues. Despite some of financial instrument such as Negotiable Certificate of Deposits (NCDs) has been established by the central bank in order to push up the creation of the interbank market in Cambodia, but this operating process seem to be a bit late. Surprisingly, for a very long period of time, the early warning model of banks failure has not been studied and developed yet in Cambodia banking industry. In addition, approximately one third of the compliance based bankers have ever learned about CAMEL and not many of banks do apply early warning model in assessing bank stability or survivor rate.

The central bank should continue harder to promote the participation of commercial banks in the interbank market aim to reduce the amount of liquidities holding by banks through investing those excessed liquidities in financial instrument as such NCDs. The financial assets which are invested and hold by banks could have helped banks generate more interest revenues and increase banks' profits. More importantly, each bank can pledge financial assets hold in balance sheet as collateral in order to request short term loan from the other banks in case of needed liquidity. More interestingly, this mechanism would have increased the availability of banks' credit available in the economy which might have reduce the level of interest rate, boost up domestic investment and economic growth in the whole country.

In addition, the central bank should have considered the process of creating early warning model of banks failure that shall be used by central bank policy makers as a tool for policy formulation or decision in order to cope with banking crisis or financial instability that might have occurred in the future. At the same time, short and long term training courses, related to CAMEL, Bank Stress test, or other techniques shall be arranged and provided by the central bank to all of commercial bankers especially

compliance based bakers to learned about model based risk management. As revealed by this research most of the bakers are willing to join and learn about those methods or technique in assessing bank's performance and bank's risk.

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APPENDIX

Questionnaire

I am conducting a research topic, "Early Warning of Banks Failure in Cambodia: Cox's Proportional Hazard Model". The main purpose of this topic is to predict the survivor rate of all banks in Cambodia for the period of four and five years by employing the Cox's Proportional Hazard Model with CAMEL. Beside that this study is also trying to investigate which methods or techniques that are being used by banks to evaluate its performance or being used as an early warning system. The contribution of your time in responding to this questionnaire will make this research be completed successfully. Your responding to this questionnaire will be kept as secret and you are not required provide the name of your bank as well as your name.

1. Gender

   ☐ Male ☐ Female

2. Which section of the bank do you work?
   :_____

3. What level of position which you currently hold or work with?

   ☐ Senior

   ☐ Manager

   ☐ Team Head (top management team)

4. Does your bank is a local, foreign or co-operation between local and foreign bank?

   ☐ Local bank ☐ Foreign bank

   ☐ Co-operation between local and foreign bank

5. Have you ever learned about CAMELS?

   ☐ Yes ☐ No

6. Have your bank ever used any kind of models to predict the survivor rate of the bank for the next few years?

   ☐ Yes ☐ No

7. Do you know what Cox's Proportional Hazard model is?

   ☐ Yes ☐ No

8. What kind of methods or techniques does your bank use to evaluate bank's performance and risk?

   ☐ Methods introduced by National Bank of

Cambodia

- ☐ Bank Stress test
- ☐ CAMELS
- ☐ Cox's Proportional Hazard model
- ☐ Others

9. If you are offered to join a workshop or seminar to learn about Bank Stress test, CAMELS, or Cox Proportional Hazard model which could be used to assess your bank's performance and risk, how strongly would you be likely willing to joint?

   ☐ Less likely ☐ Likely ☐ Strongly
   ☐ Very Strongly

10. If this kind of workshop or seminar as mention in question (10) is really does exist, how strongly would you introduce this workshop or seminar to your friends or bank to joint?

    ☐ Less likely ☐ Likely ☐ Strongly
    ☐ Very Strongly

Thank you!!!