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Do the Choices of Indicators Affect the Predictability in Modeling an Early Warning System for Currency Crisis? An Analysis

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Abstract: Currency crisis is like a never ending episode in the economic story. It occurs anytime and sometimes without any warning. Previous studies showed that researchers can actually see the sign of the crisis before it occurs. But the questions left are how accurate the sign given and what variables should researchers look up to see this 'signal'? This study's aim to see the signal through International Country Risk Guide indicators by using the famous method by Kaminsky and Reinhart in modeling an early warning system. Researchers compared the performance of International Country Risk Guide with selected 12 macroeconomic indicators for 10 countries. Besides studying the signal of crisis from different types of data, researchers also have conducted an experiment in predicting future currency crisis by using logit method and another method from the previous study on macroeconomic indicators which is k-nearest neighbour method. The findings showed that the ICRG indicators give better prediction than macroeconomic indicators. The signal for crisis shown in every country by using the ICRG indicators is almost accurate except for South Africa. For the prediction results, k-nearest neighbour method is quite comparable to logit method.

Key words: International country risk guide, k-nearest neighbour method, logit, signaling approach, episode, currency crisis

INTRODUCTION

There are so many unpredictable things happened in this life. Things like natural disaster, war, disease and others. Even there is a system so called Early Warning System (EWS) that already exist a long time ago to help us prepare for the unexpected event like an earthquake, still the prediction is not always accurate. Researchers have done their best to improve the system so that researchers are well prepared to face the same crisis if it occurs again. With the development of technologies as well as methodologies that still undiscovered, researchers never give up to model a better EWS for the future.

Like others, EWS in predicting financial or currency crises are not something new. The warning system had been proposed as early as in 1979. The first generation model had been created by Krugman (1979) and Flood and Garber (1984). It was created in order to investigate the reason of the frequently discontinuous devaluations of the Mexican exchange rate that happened from 1973-1982 and for Argentina that happened in 1978 until 1981. Since, currency crisis happened due to slowly deplete of international reserves, Flood and Garber had used this theory in their model by fixing the time of the crisis which mean before the crisis happened, the balance of the reserves was sufficient in fulfilling the foreign currency demands of market participants. The outbreak of the 1992-1993 European Exchange Rate Mechanism (ERM) crises had led economists and researchers to the innovation of the new early warning system which also known as second generation model. This model was created by Obstfeld (1994, 1997), Radelet and Sachs (1998) and Ozkan and Sutherland (1995). This model differs from previous model, since it can trigger a crisis without depending on the basis of macroeconomic. Hence, a crisis may occur if investors change their prospect to the stability of exchange rate even economic policies seems more reliable with the fixed exchange regime.

The need for third generation model showed in the 1990s due to the Mexican Tequila in 1994 and the Asian Financial Crisis 1997. There were lots of theoretical explanations in this model, since now researchers and economists had to deal with the crises that can spread to other countries (contagious). Some researchers proposed theories like hidden or clear public guarantees and not enough banking regulation system are the factors of the financial weakness (Krugman, 1998; Corsetti *et al*., 1998). There are also others that proposed theories on financial weakness based on the increasing of short-term foreign debt.

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Since, the crisis cost was very high based on its effect to the percentage of unemployment, economic reduction and requirement to restructure financial process, researchers and economists decided to start on empirical studies. It was the starting of the new literature where there were lots of studies based on the leading indicators of currency crisis. Besides signaling approach, probit and logit, there were researches conducted by using Markov switching, artificial neural network, fisher discriminant analysis, Vector Auto Regression (VAR) and machine learning. Even, so many empirical studies had been done to find which indicators give more effect on the currency crisis, there is no study yet that uses the International Country Risk Guide (ICRG) variables as indicators. The ICRG rating consists of 22 indicators in 3 different subcategories of risk which are financial, economic and political. There is a different index for each subcategory such that the political risk index is based on 100 points while financial and economic risk on 50 points each. The risk is calculated by summation of all points from those 3 subcategories and then divided by 2 to get its weights which also known as composite country risk score. The range of the composite country risk score has different categorization where from 80 points and above has been categorized as very low risk and 49.9 points and below is the opposite.

The ICRG model is actually made to forecast financial, economic and political risk. It was created as early as in 1980 which exactly 33 years ago. The editors of international reports who created this ICRG model generated a statistical model to compute risks which also come with an explanation of the analysis of the numbers and observe something that do not show explicitly by the numbers. Even, the ICRG model already present a year after the first generation crisis model was created, there is no research had been conducted to prove that may be indicators in the ICRG model do work in predicting currency crisis. Therefore, this study applies the ICRG indicators with hope to see if there is any interaction between the occurrence of currency crisis with indicators of financial, economic and political risk. The focus is on the Asian crisis 1997 countries which are Malaysia, Indonesia, the Philippines, Thailand and South Korea as well as on other countries that have a currency crisis history like Turkey, Argentina, Mexico, Brazil and South Africa.

Literature review: The first empirical study for the EWS in detecting currency crisis that had been developed by Kaminsky *et al.* (1998) used signaling approach. Its study consists of 15 macroeconomic indicators based on the availability of monthly data with an estimation of optimal threshold for each country which is needed in the determination of the indicators that can maximize the correct signal and minimize the false alarm. Its scope for any signal is fixed at 24 months and their study defined currency crisis as a higher decreasing of the international reserves or currency. Also, crisis index was calculated by using a weighted average monthly percentage change in the exchange rates and reserves with positive and negative weights attached so that the 2 components of the index have balance conditional volatilities. Based on the index, the period is in a crisis period whenever the index mean is >3σ. A year after that, the signal approach was further applied by Kaminsky and Reinhart (1999). Kaminsky and Reinhart (1999) put their analysis directly by constructing their model in a way where the leading indicators had been taken as the signaling indicators. Each indicator is then weighted by the inverse of its Noise-To-Signal (NTS) ratio. According to NTS ratio, some information like the vulnerability of an economy in an upcoming crisis can be known.

Table 1: The technique of the signals approach

Signals approach	Crisis within 24 months	No crisis within 24 months
Signal was issued	A	B
No signal was issued	C	D

The technique of the signals approach is as shown in Table 1. An indicator is said to signal a crisis if it shows drastic changes before or during a crisis. In this case which is case A, it is said that an indicator produces a really good signal. If an indicator signal an issue but there is no crisis occurs in the future date, it will be categorized as a bad signal or also known as case B. In case C, an indicator does not show any signal like in case A but the difference is in this case there is a crisis occurs. Case D is when an indicator remains silent whenever there is no crisis at all. Generally, the noise-to-signal ratio (NTS ratio), ω_j is defined as:

$$\omega_j = \frac{[B/(B+D)]}{[A/(A+C)]} \quad (1)$$

Where:

A = No. of good signal was sent
B = No. of false alarm
C = No. of no signal was sent but there is a crisis
D = No. of no signal was sent and no crisis at all

Soon after, study on early warning by using replication of Kaminsky *et al.* (1998) results had been done by Edison (2003). In her research, besides expanding the number of indicators and the country coverage, she

also made an observation on regional differences and compared the existing algorithm. The threshold that had been set up for this study was 2.5σ. By using 14 indicators to test on 20 developing and industrial countries from 1970-1998, the results of the study showed that the performance of the model was robust to various sensitivity tests and it also helped in identification of vulnerabilities. Bad news for this research was the model gave too many false alarms which make it failed to be a good reference of early warning systems.

The other research that had been done by using signal approach as a method was Bruggemann *et al.* (2002). Differ with Edison in their study they used an extension of the signal approach. They extended the signal approach from previous studies by incorporating additional elements, namely the strength of the signal, the timing of the signal while keeping the prognostic quality of an indicator. Although, the development of the composite indicator gave some indication about the vulnerability of a country in a crisis, it did not allow drawing any conclusions about the probability of the occurrence of a crisis. Their model showed that the crises in central and Eastern Europe occurred because of the same reason the occurrence of the crises as in other emerging markets. They also found that the declining number in exports and currency reserves plus an overvalued of exchange rate made good predictive power in assessing crisis vulnerabilities.

Perks of using signal approach are the results quite easy to understand, hence it made easy to assess each indicator's predictability. Nevertheless, the actual causes of the crisis may be incomprehensible as the relation between variables is overlooked. An additional negative aspect of this method is the explanatory indicators also the probability of a crisis where both of them had been defined as a step function. Therefore, the model does not succeed in differentiating whether the value of the indicators already exceeds or pass the threshold. This method is impractical to be tested by any standard statistical tests too. To overcome several disadvantages, some researchers choose to solve it by using discrete-choice or limited-dependent models such as logit or probit regression. Logit or probit can be used to predict the outcome, since the probability of crisis range from 0-1.

The earliest study on logit or probit was done by Eichengreen *et al.* (1996). Their studies used quarterly macroeconomic and political data from 1959-1993 which covering 20 industrial countries in order to investigate the main cause of this crisis and its contagious factor. They defined crisis using Exchange Market Pressure (EMP) and the crisis can be detected if the value of EMP is more than its mean plus 1.5 of its standard deviation. Another study that practiced this type of method was Frankel and Rose (1996) which applied the probit model to approximate the probability of crisis annually. They took 105 developing countries as their sample and the period taken were from 1971-1992. They used the theory that currency crisis has tendency to happen when the foreign interest rates and domestic credit growth are high while the growth of output and FDI are low. In other studies, Kumar *et al.* (2002) put their focus more in predicting a crisis by using a logit model on 32 developing countries from the year 1985-1999. They assessed their prediction by using out-of-sample and finally predicting a crisis based on the balance sample. It was stated in some studies that their model has quite a good forecasting ability. Yet, studies that had been conducted after it quite similar, since most of the studies applied these frequently indicators. It is not easy to confirm if researchers have already discovered the suitable indicators. That is because in this study, researchers want to investigate the causes of currency crisis by using a logit model with the ICRG risk indicators so that the status of the recent study can be improved.

MATERIALS AND METHODS

Logistic regression analysis (logit) is a technique that used to approximate the probability of an event by predicting a binary dependent outcome of a set of independent indicators. In the case of predicting currency crisis occur or not, researchers let M as countries and I = {1, 2,.., M} that are observed during T periods, t = {1, 2,..., T}. For each country and each quarter, researchers examine the binary dependent variable Y.

$$Y=\begin{cases}1 \text{ with probability } Pr(Y=1)=P\\ 0 \text{ with probability } Pr(Y=0)=1-P\end{cases} \quad (2)$$

The crisis index Y is correlated with a set of L independent indicators X. Thus, X is a LM times T matrix of observations. This model's objective is to approximate the effect of the indicators X on the probability P. Researchers let τ, as the vector of L marginal effects:

$$\tau=\frac{dp}{dX'} \quad (3)$$

In logit or probit models, the probability of a crisis is a non-linear function of the indicators:

$$Pr(Y=1)=F(X\beta) \quad (4)$$

By using a logit model:

$$\Pr(Y=1)=F(X\beta)=\frac{e^{X\beta}}{1+e^{X\beta}} \quad (5)$$

Then in the logit model, the effect of the indicators on the odds is defined as:

$$\Omega(Y=1|X)=\frac{P}{1-P}=e^{X\beta} \quad (6)$$

The effect of the indicators on the odds ratio, given 2 realizations of X which are as X_0 and X_1:

$$\frac{\Omega(Y=1|X_1)}{\Omega(Y=1|X_0)}=e^{(X_1-X_0)\beta} \quad (7)$$

The odds ratio gives a picture on how the odds of observing Y = 1 change when X moves from X_1 to X_0. Their nonlinearity is a main property of logit model. Therefore, the odds ratio of Eq. 7 point out that the marginal effect of a change on the independent indicators on the probability of the crisis, Y is not constant but depends on the precise state of the independent indicators X.

Indicators: The tested macroeconomic indicators were selected based on the previous empirical literature and the availability of the data. The 12 macroeconomic indicators that had been selected in this study were exports of goods and services, foreign direct investment, M2 multiplier, imports of goods and services, consumer price index, foreign exchange reserves, general government final consumption, industrial production index, real effective exchange rate, GDP per capita, terms of trade and unemployment rate.

For the ICRG indicators, there are 22 variables in 3 subcategories where 12 variables for political risk components, 5 variables for economic risk and 5 variables for financial risk. The higher the score for each variable indicates that the risk is very low while the lower the score or up to 0 points for each variable indicates the opposite. However, not all variables indicate a sign of crisis or risk. For example, variables like investment profile, democratic accountability, government stability, bureaucracy quality, law and order, ethnic tensions, religious tensions and military in politics. All of these variables are from political risk components. The rest of the variables showed a sign yet it was not really accurate for certain country. Results for the signaling approach of these variables can be seen in the study and the accuracy of the prediction was based on the variables from signaling approach results, since researchers decided not to take all variables in the experiment.

Sample and data: Researchers tested the model quarterly for 10 countries and the period taken were from Q2 1985 until Q4 2001. The sample included most of South Asian countries based on Asian financial crisis 1997 also other countries that had been experienced, such currency crisis like Mexico, Argentina, Brazil, Turkey and South Africa. All the data for macroeconomic indicators were downloaded under analysis via Datastream while all the data for the ICRG indicators were downloaded through its website. Researchers chose quarterly data instead of annually and monthly because certain countries data for some indicators only available for the quarter and above.

Even though, it's unproblematic to access data annually, somehow it has some weakness like annual data make the prediction values of leading indicators less accurate. By using data annually, it also makes the precision of crisis time unclear, since researchers could not really know whether the crisis takes place at the beginning of the year or the end. For example, the currency crisis for Asian that started with Thailand had happened on third quarter in 1997. If researchers took the data as annually, the crisis could be assumed to happen earlier or later than that in 1997.

RESULTS AND DISCUSSION

In this study, signaling approach had been used to filter which indicators have a good forecasting ability for a currency crisis. For macroeconomic indicators, all 12 indicators had a Noise-To-Signal (NTS) ratio smaller than one as can be seen in Fig. 1. The best indicators were M2 multiplier (NTS ratio: 0.0819), GDP per capita (NTS ratio: 0.2121), unemployment rate (NTS ratio: 0.2150), real effective exchange rate (NTS ratio: 0.2246), industrial production index (NTS ratio: 0.3244), foreign direct

Fig. 1: Noise-to-signal ratio of the macroeconomic indicators

investment (NTS ratio: 0.3444), consumer price index (NTS ratio: 0.36), foreign exchange reserves (NTS ratio: 0.3784), terms of trade (NTS ratio: 0.4866), general government final consumption (NTS ratio: 0.5122), imports of goods and services (NTS ratio: 0.5802) and exports of goods and services (NTS ratio: 0.5989).

M2 multiplier gave a higher signal compared to other indicators. It seems like M2 multiplier is highly related to currency crises. Theoretically, currency crisis can only occurs under a fixed exchange rate regime which in this case, it explains much why M2 multiplier and the real effective exchange rate indicated quite good signal and low NTS ratio. For the ICRG indicators, only 11 indicators out of 22 indicators had a NTS ratio <1 as can be seen in Table 2. These indicators were then to be used in predicting a crisis for each country. When calculating the NTS ratio of the individual indicators for both types of data using in-sample model, it's getting clear that macroeconomic indicators perform best. Additionally, these indicators captured the general condition of the economy for instance unemployment rate and GDP per capita. On the other hand, the results of the signaling approach of the ICRG model showed that politics did not have much effect on the occurrence of the crisis. This is because only 3 out of 12 indicators showed the signal. In the study, researchers chose to focus more on individual indicators than summation of these 3 subcategories or the composite risk rating because when researchers analyzed the signal from the composite risk rating, there was no signal for any country. In another side, financial risk rating showed clearer signal than economic and political risk.

Table 2: Noise-to-signal ratio of the ICRG indicators

Variables	Noise-to-signal ratio
Political	
Bureaucracy quality (L)	NA
Corruption (F)	1.4912
Democratic accountability (K)	NA
Ethnic tensions (J)	NA
External conflict (E)	0.4530
Government stability (A)	NA
Internal conflict (D)	0.2597
Investment profile (C)	NA
Law and order (I)	NA
Military in politics (G)	NA
Religious tensions (H)	NA
Socioeconomic conditions (B)	0.4801
Financial	
Risk for current account as % of XGS	0.1323
Risk for debt service	0.2984
Risk for exchange rate stability	0.0990
Risk for foreign debt	1.0077
Risk for International liquidity	0.6132
Economic	
Risk for budget balance	0.2298
Risk for current account as % of GDP	3.2552
Risk for GDP growth	0.1887
Risk for inflation	0.6034
Risk for per capita GDP	0.3397

Since, the aim is also to see which type of data gives higher accuracy in predicting the crisis, the prediction for each country was made by using the logit model via SPSS software. The results for both macroeconomic and the ICRG indicator are shown as in Fig. 2.

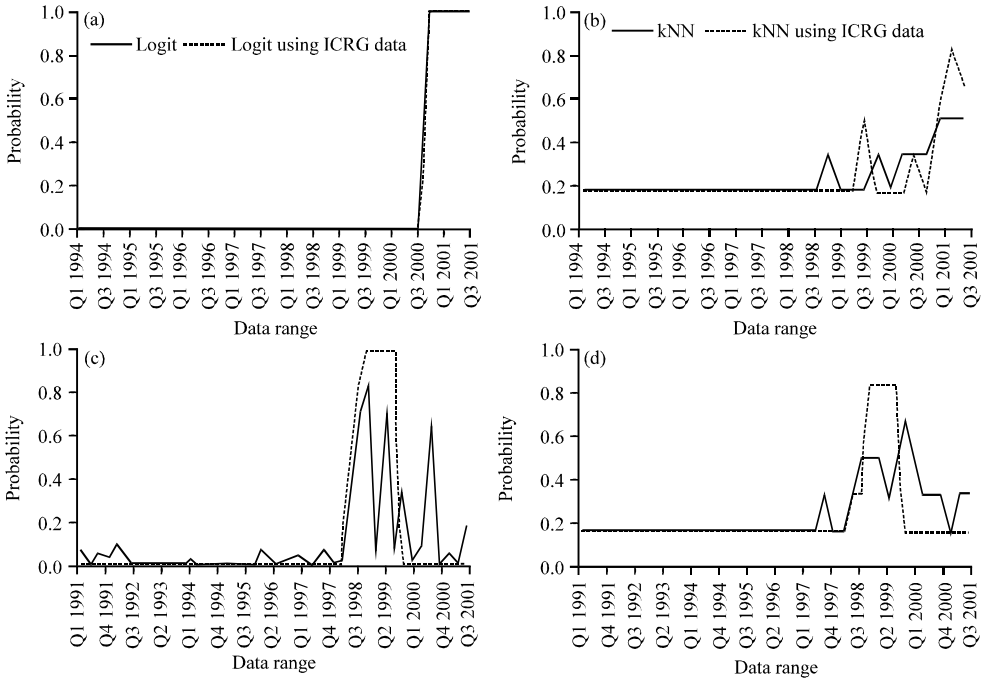
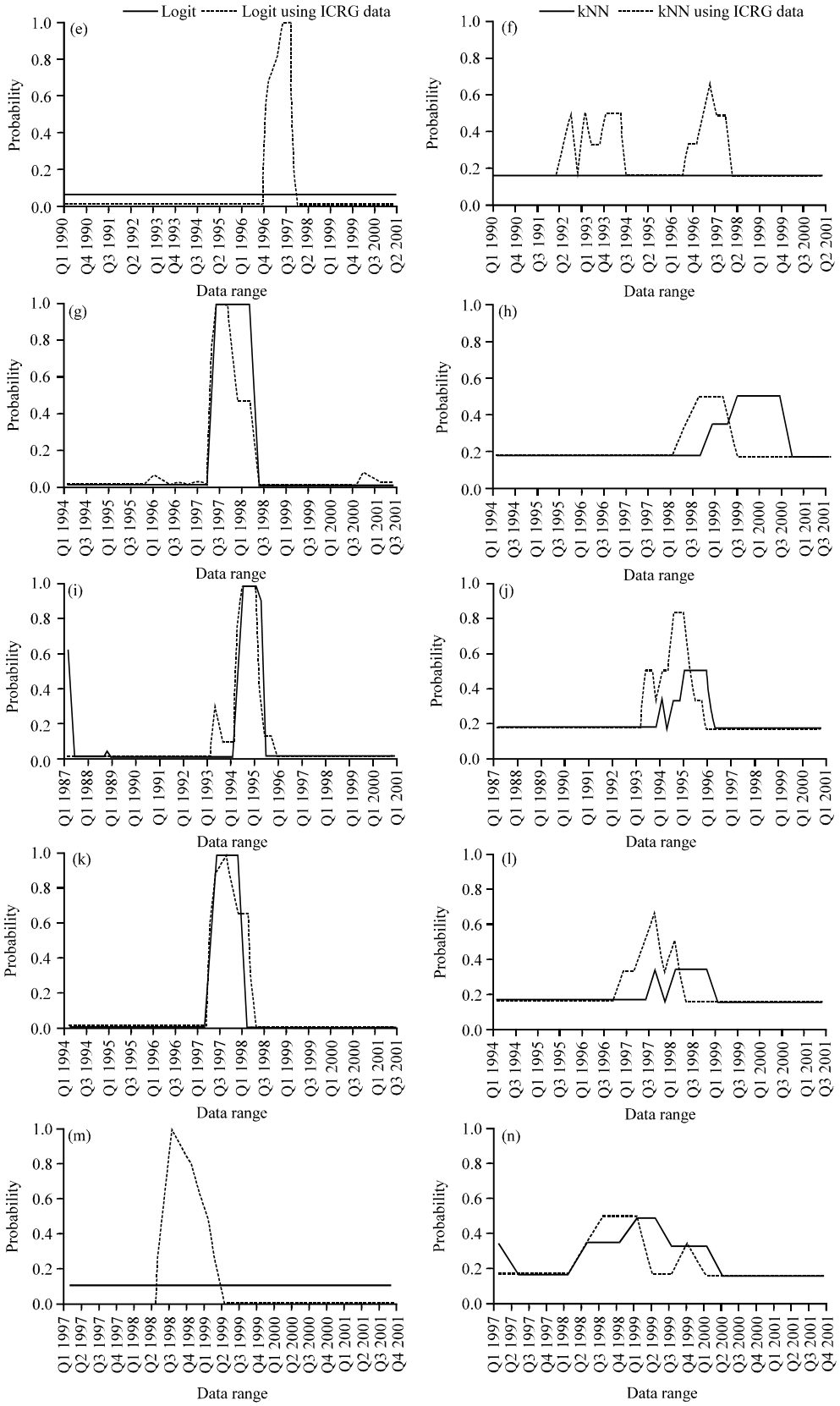


Fig. 2: Continue



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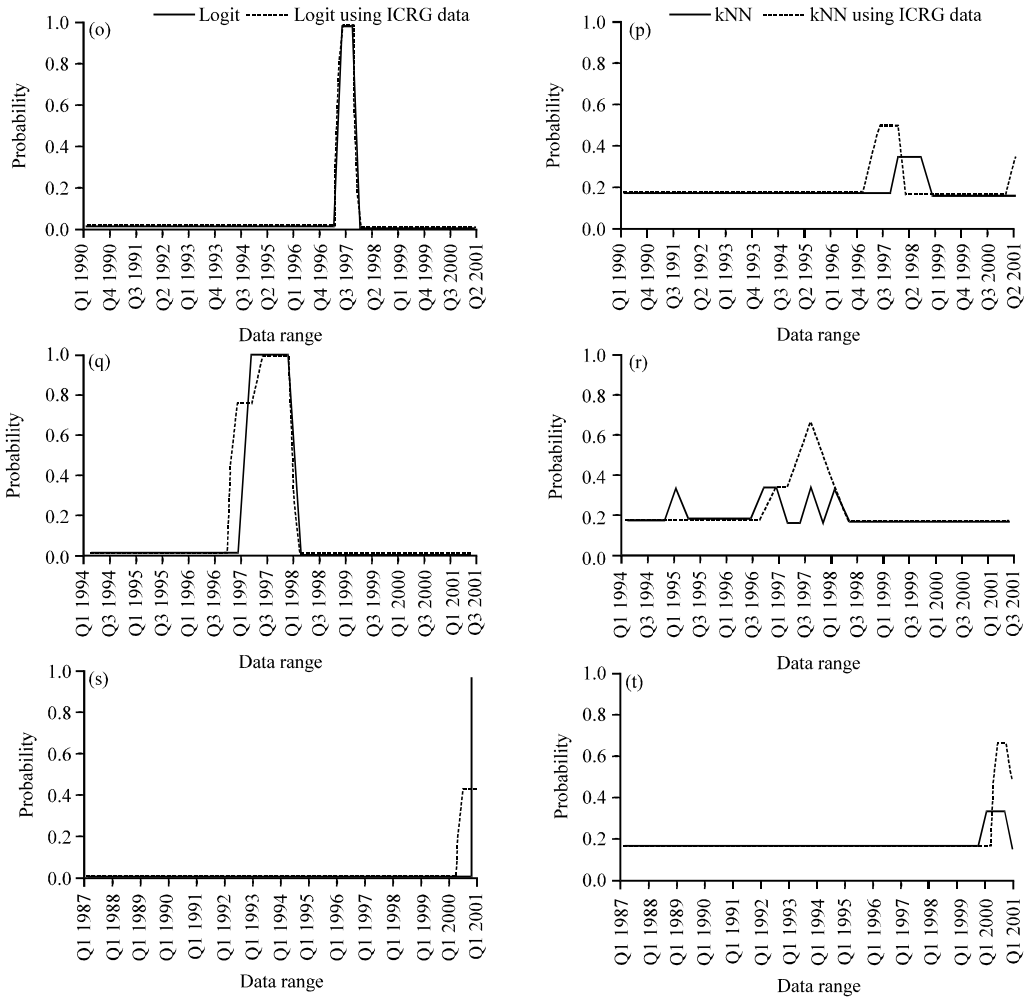

Fig. 2: The probability plot of crisis for each country by using logit and kNN methods with different types of data: a, b) Argentina; c, d) Brazli; e, f) Indonesia; g, h) Malaysia; I, j) Mexico; k, l) Philippines; m, n) South Africa; o, p) South Korea; q, r) Thailand; s, t) Turkey

Table 3: Classification of the currency crisis prediction by using the logit method

			PRS indicators			Macroeconomic indicators		
Country	Partition	Observed	No crisis	Crisis	Correct (%)	No crisis	Crisis	Correct (%)
Argentina	Step 0	No crisis	189	0	100.0	28	0	100.0
		Crisis	12	0	0.0	4	0	0.0
		Overall percentage			94.0			87.5
	Step 1	No crisis	189	0	100.0	28	0	100.0
		Crisis	0	12	100.0	1	3	75.0
		Overall percentage			100.0			96.9
Brazil	Step 0	No crisis	186	0	100.0	39	0	100.0
		Crisis	15	0	0.0	5	0	0.0
		Overall percentage			92.5			88.6
	Step 2	No crisis	185	1	99.5	38	1	97.4
		Crisis	4	11	73.3	2	3	60.0
		Overall percentage			97.5			93.2
Indonesia	Step 0	No crisis	192	0	100.0	45	0	100.0
		Crisis	9	0	0.0	3	0	0.0
		Overall percentage			95.5			93.8
	Step 1	No crisis	192	0	100.0	45	0	100.0
		Crisis	6	3	33.3	0	3	100.0
		Overall percentage			97.0			100.0

Table 3: Continue

			PRS indicators			Macroeconomic indicators		
Country	Partition	Observed	No crisis	Crisis	Correct (%)	No crisis	Crisis	Correct (%)
Malaysia	Step 0	No crisis	192	0	100.0	28	0	100.0
		Crisis	9	0	0.0	4	0	0.0
		Overall percentage			95.5			87.5
	Step 1	No crisis	192	0	100.0	28	0	100.0
		Crisis	5	4	44.4	0	4	100.0
		Overall percentage			97.5			100.0
Mexico	Step 0	No crisis	186	0	100.0	55	0	100.0
		Crisis	15	0	0.0	5	0	0.0
		Overall percentage			92.5			91.7
	Step 2	No crisis	180	6	96.8	54	1	98.2
		Crisis	3	12	80.0	1	4	80.0
		Overall percentage			95.5			96.7
South Africa	Step 0	No crisis	195	0	100.0	63	0	100.0
		Crisis	6	0	0.0	2	0	0.0
		Overall percentage			97.0			96.9
	Step 1	No crisis	195	0	100.0	63	0	100.0
		Crisis	1	5	83.3	0	2	100.0
		Overall percentage			99.5			100.0
South Korea	Step 0	No crisis	195	0	100.0	46	0	100.0
		Crisis	6	0	0.0	2	0	0.0
		Overall percentage			97.0			95.8
	Step 1	No crisis	195	0	100.0	46	0	100.0
		Crisis	0	6	100.0	2	0	0.0
		Overall percentage			100.0			95.8
Philippines	Step 0	No crisis	192	0	100.0	29	0	100.0
		Crisis	9	0	0.0	3	0	0.0
		Overall percentage			95.5			90.6
	Step 2	No crisis	190	2	99.0	29	0	100.0
		Crisis	0	9	100.0	1	2	66.7
		Overall percentage			99.0			96.9
Thailand	Step 0	No crisis	189	0	100.0	28	0	100.0
		Crisis	12	0	0.0	4	0	0.0
		Overall percentage			94.0			87.5
	Step 2	No crisis	188	1	99.5	28	0	100.0
		Crisis	0	12	100.0	4	0	0.0
		Overall percentage			99.5			87.5
Turkey	Step 0	No crisis	198	0	100.0	59	0	100.0
		Crisis	3	0	0.0	1	0	0.0
		Overall percentage			98.5			98.3
	Step 1	No crisis	198	0	100.0	59	0	100.0
		Crisis	3	0	0.0	0	1	100.0
		Overall percentage			98.5			100.0

The cut value is 0.500

Table 4: Classification of the currency crisis prediction by using the kNN method

			PRS indicators			Macroeconomic indicators		
Country	Partition	Observed	No crisis	Crisis	Correct (%)	No crisis	Crisis	Correct (%)
Argentina	Training	No crisis	117.0	0.0	100.0	19.0	0.0	100.0
		Crisis	3.0	3.0	50.0	3.0	0.0	0.0
		Overall percentage	97.6	2.4	97.6	100.0	0.0	86.4
	Holdout	No crisis	72.0	0.0	100.0	9.0	0.0	100.0
		Crisis	5.0	1.0	16.7	1.0	0.0	0.0
		Overall percentage	98.7	1.3	93.6	100.0	0.0	90.0
Brazil	Training	No crisis	114.0	0.0	100.0	23.0	1.0	95.8
		Crisis	1.0	8.0	88.9	4.0	0.0	0.0
		Overall percentage	93.5	6.5	99.2	96.4	3.6	82.1
	Holdout	No crisis	72.0	0.0	100.0	15.0	0.0	100.0
		Crisis	3.0	3.0	50.0	1.0	0.0	0.0
		Overall percentage	96.2	3.8	96.2	100.0	0.0	93.8
Indonesia	Training	No crisis	103.0	0.0	100.0	28.0	0.0	100.0
		Crisis	5.0	0.0	0.0	2.0	0.0	0.0
		Overall percentage	100.0	0.0	95.4	100.0	0.0	93.3
	Holdout	No crisis	89.0	0.0	100.0	17.0	0.0	100.0
		Crisis	3.0	1.0	25.0	1.0	0.0	0.0
		Overall percentage	98.9	1.1	96.8	100.0	0.0	94.4
Malaysia	Training	No crisis	123.0	0.0	100.0	20.0	0.0	100.0

Table 4: Continue

			PRS indicators			Macroeconomic indicators		
Country	Partition	Observed	No crisis	Crisis	Correct (%)	No crisis	Crisis	Correct (%)
		Crisis	4.0	0.0	0.0	2.0	0.0	0.0
		Overall percentage	100.0	0.0	96.9	100.0	0.0	90.9
	Holdout	No crisis	69.0	0.0	100.0	8.0	0.0	100.0
		Crisis	4.0	1.0	20.0	2.0	0.0	0.0
		Overall percentage	98.6	1.4	94.6	100.0	0.0	80.0
Mexico	Training	No crisis	125.0	0.0	100.0	37.0	0.0	100.0
		Crisis	5.0	6.0	54.5	3.0	0.0	0.0
		Overall percentage	95.6	4.4	96.3	100.0	0.0	92.5
	Holdout	No crisis	61.0	0.0	100.0	18.0	0.0	100.0
		Crisis	2.0	2.0	50.0	2.0	0.0	0.0
		Overall percentage	96.9	3.1	96.9	100.0	0.0	90.0
South Africa	Training	No crisis	109.0	0.0	100.0	12.0	0.0	100.0
		Crisis	3.0	1.0	25.0	2.0	0.0	0.0
		Overall percentage	99.1	0.9	97.3	100.0	0.0	85.7
	Holdout	No crisis	86.0	0.0	100.0	6.0	0.0	100.0
		Crisis	1.0	1.0	50.0	0.0	0.0	0.0
		Overall percentage	98.9	1.1	98.9	100.0	0.0	100.0
South Korea	Training	No crisis	125.0	0.0	100.0	29.0	0.0	100.0
		Crisis	5.0	0.0	0.0	2.0	0.0	0.0
		Overall percentage	100.0	0.0	96.2	100.0	0.0	93.5
	Holdout	No crisis	70.0	0.0	100.0	17.0	0.0	100.0
		Crisis	1.0	0.0	0.0	0.0	0.0	0.0
		Overall percentage	100.0	0.0	98.6	100.0	0.0	100.0
Philippines	Training	No crisis	114.0	0.0	100.0	21.0	0.0	100.0
		Crisis	5.0	0.0	0.0	1.0	0.0	0.0
		Overall percentage	100.0	0.0	95.8	100.0	0.0	95.5
	Holdout	No crisis	78.0	0.0	100.0	8.0	0.0	100.0
		Crisis	3.0	1.0	25.0	2.0	0.0	0.0
		Overall percentage	98.8	1.2	96.3	100.0	0.0	80.0
Thailand	Training	No crisis	109.0	0.0	100.0	20.0	0.0	100.0
		Crisis	4.0	5.0	55.6	2.0	0.0	0.0
		Overall percentage	95.8	4.2	96.6	100.0	0.0	90.9
	Holdout	No crisis	80.0	0.0	100.0	8.0	0.0	100.0
		Crisis	2.0	1.0	33.3	2.0	0.0	0.0
		Overall percentage	98.8	1.2	97.6	100.0	0.0	80.0
Turkey	Training	No crisis	120.0	2.0	98.4	39.0	0.0	100.0
		Crisis	3.0	0.0	0.0	1.0	0.0	0.0
		Overall percentage	98.4	1.6	96.0	100.0	0.0	97.5
	Holdout	No crisis	75.0	1.0	98.7	20.0	0.0	100.0
		Crisis	0.0	0.0	0.0	0.0	0.0	0.0
		Overall percentage	98.7	1.3	98.7	100.0	0.0	100.0

The cut value is 0.500

Besides logit, researchers also applied k-nearest neighbour method for the sake of comparison to see which method is better. Under the same figure is the result of the prediction of currency crisis for both indicators by using kNN. Besides the probability plot, the classification of the prediction with 0.5 cut off for both methods are also displayed, as in Table 3 and 4. From the probability plot, it is clearly shown that the ICRG indicators gave better prediction than macroeconomic indicators. The signal for crisis shown in every country by using the ICRG indicators is almost accurate except for South Africa. Based on Fig. 2 also, researchers can notice that prediction results by using kNN method are quite comparable to logit method even if researchers refer to the classification table (Appendix). However, the results that researchers got through this experiment are good enough, since the study focuses more on the types of data instead of the method.

CONCLUSION

Briefly, researchers have conducted a study on the effect of the ICRG indicators on the currency crisis and which indicators affect the most in this study. By employing signaling approach method the same as was done by Kaminsky *et al*. (1998), researchers found that not all variables in the ICRG can be used to predict the currency crisis, since 8 out of 22 variables did not show any signal and 3 variables have >1 value based on their noise-to-signal ratio. Even all macroeconomic indicators have <1 value for their NTS ratio and showed signal for the crisis, however it had been failing in detecting crisis for some countries. Meanwhile, the ICRG indicators had shown excellent results in predicting currency crisis except for South Africa.

This experiment used logit and k-nearest neighbour method in predicting currency crisis for 10 countries and

the range of the data was from Q2 1985 until Q4 2001. Besides comparing the prediction within 2 different types of data, researchers also ran an experiment to see which methods outperform than another. However, both of the methods gave comparable results and it's still hard to determine which method is better. In the previous study, researchers found that kNN outperform than logit method. But, since the aim in this study stress more on the type of data instead of the method, researchers hope in the future researchers can focus more on the method by experimenting ensemble classifiers instead of single classifier.

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APPENDIX

Macroeconomic indicators explanation: World Bank, International Monetary Fund (IMF) and International Financial Statistics (IFS).

M2 multiplier: A rise of/in the money multiplier can point to inflationary problems in the future if the money demand remains unchanged. The resulting real appreciation of the exchange rate can put a peg under pressure.

Consumer price index: Consumer price index reflects changes in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used.

Exports of goods and services: Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees and other services, such as communication, construction, financial, information, business, personal and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.

Imports of goods and services: Imports of goods and services represent the value of all goods and other market services received from the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees and other services, such as communication, construction, financial, information, business, personal and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.

Foreign direct investment: Foreign direct investment is the net inflows of investment to acquire a lasting management interest (10% or more of the voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital and short-term capital as shown in the balance of payments. This series shows net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors. Data are in current US dollars.

Foreign exchange reserves: According to the International monetary fund, foreign exchange reserves are defined in the balance of payments manual (5th edition) as: Those external assets that are readily available to and controlled by monetary authorities for direct financing of payments imbalances for indirectly regulating the magnitudes of imbalances through intervention in exchange markets to affect the currency exchange rate and/or for other purposes.

General government final consumption: General government final consumption expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditure on national defense and security but excludes government military expenditures that are part of the government capital formation. Data are in current US dollars.

Industrial production index: According to IFS, the aggregate of industrial production index for the industrial countries as a group is calculated by the Statistics Department from industrial and manufacturing production indices that are published in the country pages. The index covers industrial activities in mining, quarrying, manufacturing, and electricity, gas and water. The coverage of each country's production index is detailed in the footnotes on the country pages. No attempt has been made to standardize the coverage of industrial country series before aggregation. Non-seasonally adjusted industrial production or manufacturing production indices are presented for 29 industrial countries. The aggregate index, thus includes non-seasonally adjusted production data. The aggregate index is calculated using a weighted geometric mean of country indices. The individual country production series are weighted by the 2005 value added in industry, as derived from individual countries' national accounts and expressed in US dollars. Different weighting bases 1963, 1970, 1975, 1980, 1984-86, 1990, 1995, 2000 and 2005 have been used and the index series are chain-linked by the technique of ratio splicing at the overlaps years and are shifted to the reference base 2005 = 100. The weights used in the calculation are identical in concept for all countries and covered, where possible, mining, quarrying, manufacturing and electricity, gas and water. Although industrial production data for some countries are not available for more recent periods, the aggregate index will be calculated for any period for which data for >60% of the area index aggregate have been reported.

Real effective exchange rate: Real effective exchange rate is the nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs.

GDP per capita: GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current US dollars.

Terms of trade: The terms of trade effect equals the capacity to import less exports of goods and services at constant prices.

Unemployment rate: Unemployment refers to the share of the labor force that is without work but available for and seeking employment. Definitions of labor force and unemployment differ by country.

B. ICRG indicators explanation

The political risk rating: The aim of the political risk rating is to provide a means of assessing the political stability of the countries covered by ICRG on a comparable basis. This is done by assigning risk points to a pre-set group of factors, termed political risk components. The following risk components, weights and sequence are used to produce the political risk rating.

Political risk components

Sequence	Component	Points (max.)
A	Government stability	12
B	Socioeconomic conditions	12
C	Investment profile	12
D	Internal conflict	12
E	External conflict	12
F	Corruption	6
G	Military in politics	6
H	Religious tensions	6
I	Law and order	6
J	Ethnic tensions	6
K	Democratic accountability	6
L	Bureaucracy quality	4
Total		100

The economic risk rating: The overall aim of the economic risk rating is to provide a means of assessing a country's current economic strength and weakness. In general terms where its strength outweighs its weakness it will present a low economic risk and where its weakness outweighs its strength it will present a high economic risk. These strengths and weaknesses are assessed by assigning risk points to a pre-set group of factors, termed economic risk components. Below are the economic risk components simple explanations.

GDP per head: The estimated GDP per head for a given year, converted into US dollars at the average exchange rate for that year, is expressed as a percentage of the average of the estimated total GDP of all the countries covered by ICRG.

Real GDP growth: The annual change in the estimated GDP, at constant 1990 prices, of a given country is expressed as a percentage increase or decrease.

Annual inflation rate: The estimated annual inflation rate (the unweighted average of the Consumer Price Index) is calculated as a percentage change.

Budget balance as a percentage of GDP: The estimated central government budget balance (including grants) for a given year in the national currency is expressed as a percentage of the estimated GDP for that year in the national currency.

Current account as a percentage of GDP: The estimated balance on the current account of the balance of payments for a given year, converted into US dollars at the average exchange rate for that year is expressed as a percentage of the estimated GDP of the country concerned, converted into US dollars at the average rate of exchange for the period covered.

The financial risk rating: The overall aim of the financial risk rating is to provide a means of assessing a country's ability to pay its way. In essence, this requires a system of measuring a country's ability to finance its official, commercial and trade debt obligations. This is done by assigning risk points to a pre-set group of factors, termed financial risk components. Below are the financial risk components simple explanations.

Foreign debt as a percentage of GDP: The estimated gross foreign debt in a given year, converted into US dollars at the average exchange rate for that year is expressed, as a percentage of the gross domestic product converted into US dollars at the average exchange rate for that year.

Foreign debt service as a percentage of exports of goods and services: The estimated foreign debt service, for a given year, converted into US dollars at the average exchange rate for that year is expressed as a percentage of the sum of the estimated total exports of goods and services for that year, converted into US dollars at the average exchange rate for that year.

Current account as a percentage of exports of goods and services: The balance of the current account of the balance of payments for a given year, converted into US dollars at the average exchange rate for that year is expressed as a percentage of the sum of the estimated total exports of goods and services for that year, converted into US dollars at the average exchange rate for that year.

Net international liquidity as months of import cover: The total estimated official reserves for a given year, converted into US dollars at the average exchange rate for that year, including official holdings of gold, converted into US dollars at the free market price for the period but excluding the use of IMF credits and the foreign liabilities of the monetary authorities is divided by the average monthly merchandise import cost, converted into US dollars at the average exchange rate for the period. This provides a comparative liquidity risk ratio that includes how many months of imports can be financed with reserves.

Exchange rate stability: The appreciation or depreciation of a currency against the US dollar (against the euro in the case of the USA) over a calendar year or the most recent 12 month period is calculated as the percentage change.

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