CONSTRUCTING EARLY WARNING SYSTEM OF CURRENCY CRISSES FOR INDONESIA: Leading Indicator Approach

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Abstract


Hasil dari studi ini menunjukkan bawa ada lima indikator terbaik yang memenuhi seluruh kriteria, yakni: 1) Misalignment nilai tukar ril rupiah disekitar nilai trend, 2. Pertumbuhan foreign asset dari Deposit Money Bank, 3) Surplus neraca keuangan, 4) Pertumbuhan base money, dan 5) Ratio surplus neraca keuangan terhadap GDP. Dari indikator individual terbaik, kita dapat membuat 17 indikator komposit terbaik. Diantara semua indikator, yang paling unggul adalah “VW”, kombinasi langsung antara point 1 dan 2.

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1. Introduction

The 1997-1999 currency crises series, which began in August 1997, was an unanticipated major shock to Indonesian economy. All in a sudden, Indonesia became one among victims of contagious currency crises across Asia Pacific. Starting from Thailand in June 1997, followed by the Philippines and South Korea, currency crises disease finally grabbed Indonesia.

Many financial institutions in Indonesia, either domestic or foreign institutions, had failed to predict the occurrence of the crisis. In fact, these institutions were very optimistic in judging the performance of Indonesian economy, and even some analysts believed that Indonesia would not suffer currency crisis as happened in other Asian countries. The Jakarta Composite Index (JCI) reached its peak (740.8) on 8th July 1997, only six days after Thailand abandoned its fixed exchange rate regime. Meanwhile, country risk for interest rate did not change significantly, reflecting market optimism to Indonesia’s resilience toward crisis attack.

Indonesia’s economic condition turned bad as Bank Indonesia failed to stabilize Rupiah. In July 1997, Rupiah was depreciated by 0.2% toward US Dollar from its average exchange rate in June 1997. On 11th June 1997, Bank Indonesia widened the exchange rate band from 8% to 12%, but this effort was fruitless. Compared to the average exchange rate of Rupiah to US Dollar in June 1997, Rupiah had dropped by 12.6% in August, 19.9% in September, 32.3% in October, 29.9% in November, and 50.2% in December 1997.

Facing currency crisis, Foreign Direct Investment (FDI) and portfolio investment to Indonesia saw significant declines in the third and fourth quarter of 1997, and even fell to
negative values. Demand for US dollar sharply increased as foreign investors tried to minimize their loss by expediting their payment of foreign currency debts. Meanwhile, speculators tried to gain profit by trading foreign currencies, mainly the US Dollar. As a consequence of these simultaneous attacks, Rupiah sunk further.

In general, it can be concluded that most financial institutions in Indonesia were failed to anticipate the 1997-1999 currency crises series. Learning from past failures in anticipating currency crises, many economists have tried to develop early warning system to deal with the possibility of currency crisis occurrence in the future. The system will be very useful if it can prevent policy makers and business practitioners from severe losses caused by crisis.

This study is an attempt to develop early warning system for Indonesia. Unlike some previous early warning system studies (which use panel data of many countries accross the time, or time series data of a single country other than Indonesia), this study uses Indonesian time series data only. It is expected that this study will capture special characteristics of Indonesian economy, that cannot be revealed by panel data nor by other-country single data studies.

2. Purpose of Study and Hypothesis

The purpose of this study is to construct early warning system of currency crises for Indonesia. The early warning system should be useful to predict possibility of currency crises occurrence in the future. In order to achieve this big goal, two smaller objectives are involved:

1) Constructing early warning system of currency crises models. Individual leading indicators and composite leading indicator models are the focus in this study, hence they are constructed to be ready-to-use early warning system models.

2) Determining robust variables in all models, which will be useful for further early warning system development. These variables should be best individual leading indicators and become elements of the best composite leading indicators.

The hypothesis behind this study is that there are some variables, among all variables in examination, which perform as best individual indicators to predict currency crisis occurrence in the near future. Some of these variables may also serve as elements of the best composite indicators.
3. Currency Crisis and Its Causes

Prior to further discussion about early warning system models, it is better to understand “currency crisis” and its causes. In general, “currency crisis” is defined as a condition where extraordinary exchange market pressure abruptly changes existing exchange rate level to a new one, with relatively high difference between the previous and the new exchange rate. In many literatures, “currency crisis” term refers only to a currency devaluation or depreciation against other currency. From literatures reviewed in this study, at least four factors can be considered as causes of currency crisis: (1) excessive monetary policy and domestic credit expansion; (2) current account deterioration; (3) financial system fragility; and (4) high degree of economic openness toward foreign exposures.

Kaminsky, Lizondo, and Reinhart (1998) classified currency crisis models based on the two earliest factors as models with “traditional approach”. In traditional approach models, significant changes in macroeconomic fundamentals are main causes of currency crisis. Models based on the third factor belong to “recent (approach) models”. In recent approach models, currency crisis can occur with or without any significant changes in economic fundamentals, since interaction between economic agents’ and government’s expectations becomes the driving force that generates speculative attack to a currency. The last factor is derived from Eichengreen, Rose, and Wyplosz (1999) with regard to contagious nature of a currency crisis.

3.1 Excessive Monetary Expansion

Krugman’s model of excessive monetary expansion is considered as the pioneer work to explain causes of a currency crisis1. Based on Krugman, in a fixed exchange rate regime economy2, excessive monetary and domestic credit expansion leads to the reduction of central bank’s foreign exchange reserves (which is also reflected by the reduction of international reserves in the monetary system)3. This expansion causes excess supply of money in domestic economy, which in turn results in interest rate decline. Interest rate decline leads to capital outflows from the respective economy, hence pushes domestic currency to devaluate.

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2 In fact, Krugman’s model is also applicable to economies with “dirty” floating exchange rate regime
3 In this study, “international reserves” variable, as in the International Monetary Fund’s International Financial Statistics “total international reserves minus gold” is used as a proxy of central bank’s strength to back up monetary policies. “Total international reserves minus gold” is the sum of the items foreign exchange, reserves position in the fund, and US Dollar value of SDR holdings by monetary authorities. In brief, “total international reserves minus gold” is broader measure of monetary policy backup rather than merely foreign exchange held by central bank.
In order to maintain current exchange rate level, central bank will have to sell foreign currencies from its reserves. If central bank does not have sufficient foreign currencies to intervene the market, devaluation seems to be the only option left. In brief, in Krugman’s model of excessive monetary expansion, lack of international reserves is the main trigger of currency crisis.

Many variables related to base money (M0), narrow money (M1), quasi-money, and broad money (M2) might be useful to determine whether excessive monetary expansion does or does not occur in domestic economy. M0, M1, quasi money, and M2 growth rates and multipliers, for example, are measures for money growth and money creation velocity. The higher the value of these variables, the more money circulated in domestic economy. If excessive monetary expansion is the root of a currency crisis, than these variables might be able to predict the crisis.

Other money-related variables are expressed in ratios with international reserves. Some of these variables use international reserves as the numerator of the ratio, while others put international reserves as the denominator. If international reserves is treated as the numerator, the ratio reflects support provided by international reserves to current money circulated. For instance, “international reserves to base money ratio” measures how many units of international reserves support each unit of base money in circulation. Higher value of this ratios reflects stronger backup of international reserves to the respective money circulation.

Conversely, if international reserves acts as the denominator, the ratio measures money creation velocity with regard to international reserves. “Base money to international reserves ratio”, for example, measures how many units of base money created per each unit of international reserves. The higher this ratios, the higher money creation velocity with regard to international reserves.

In brief, variables that can be derived for early warning system preliminary test based on “excessive monetary expansion” argument are: (1) base money (M0) growth; (2) base money / international reserves; (3) international reserves / base money; (4) narrow money (M1) growth; (5) narrow money / international reserves; (6) international reserves / narrow money; (7) narrow money multiplier; (8) seasonally adjusted narrow money (M1SA) growth; (9) seasonally adjusted narrow money / international reserves; (10) international reserves / seasonally adjusted narrow money; (11) seasonally adjusted narrow money multiplier; (12) quasi money growth; (13) quasi money / international reserves; (14) international reserves / quasi money; (15) quasi money multiplier; (16) broad money (M2) growth; (17) broad
money / international reserves; (18) international reserves / broad money; (19) broad money multiplier; (20) monetary authority’s foreign assets growth; (21) monetary authority’s foreign assets / total assets; (22) monetary authority’s foreign liabilities growth; (23) monetary authority’s foreign liabilities / total liabilities; (24) foreign assets growth in monetary system; (25) foreign assets to total assets ratio in monetary system; (26) credit to private sector (private lending) growth in monetary system; and (27) domestic credit growth in monetary system.

### 3.2 Current Account Deterioration

Current account deterioration is also considered as one cause of currency crisis in other models of currency crisis. In an economy where services only contributes insignificant share to balance of payment, trade balance is sufficient as an object of observation for current account. Rajan, Sen, and Siregar (2000) had proven that trade imbalance (here means: trade balance deficit) was a fundamental factor that causes Thailand currency crises in 1997.

Higher trade balance deficit means lower amount of foreign exchange earned from a country’s exports, compared to the amount of foreign exchange used to finance the respective country’s imports. As a consequence, higher trade balance deficit reflects higher demands for foreign currency and leads to foreign reserves depletion in monetary system. This, in turn, will result in stronger pressure for domestic currency to depreciate or devaluate.

Among all variables that affect trade balance, real effective exchange rate (REER) seems to play very significant role. REER is a measure of a country’s exports competitiveness in the world market. Higher REER (here means stronger domestic currency) means lower competitiveness of the respective country’s export products. Conversely, lower REER reflects higher competitiveness of a country’s export products. In other words, lower REER tends to stimulate exports, while higher REER curbs exports. Since REER might be useful to predict future trade balance condition and hence to predict future currency crisis, REER and other REER-related variables should be included in early warning system preliminary test.

REER misalignment over its par value is used to determine whether a domestic currency is undervalued or overvalued from its should-be value. If the current REER is below the par value (expressed by negative value of REER misalignment), the domestic currency is undervalued. On contrary, if REER is above its par value (expressed by positive value of REER misalignment), the currency is overvalued. Undervalued domestic currency implies

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4 Some “traditional approach” models as summarized by Kaminsky, Lizondo, and Reinhart (1998) consider current account as one among causes of currency crises.
that the respective country exports are still competitive in the world market, while overvalued currency is a sign that its exports are no longer competitive.

REER misalignment over its trend is a variable introduced by Bussiere and Fratzcher in their study. REER misalignment over trend is used to determine whether a domestic currency depreciates faster or slower than its trend. Positive value of this variable means that the domestic currency depreciates slower than its trend, while negative value reflects faster currency depreciation.

In brief, several variables can be derived from “current account deterioration” argument for preliminary test in this study: (1) imports growth; (2) exports growth; (3) trade balance surplus; (4) trade balance surplus growth; (5) REER; (6) REER misalignment from its equilibrium or par value; and (7) REER misalignment over its trend value.

3.3 Financial System Fragility

Other currency crisis models focus on financial system fragility. Many currency crises were preceded by financial market collapse and severe banking crises, as companies and commercial banks underwent liquidity problems. In banking crises cases, commercial banks expand their credit without retaining sufficient liquid money. As a result, when bank run occurs, many commercial banks face difficulties to fulfil their payment obligation to customers.

Liquidity problems can also come from maturity and currency mismatches. Maturity mismatch happens when a company or bank borrows short-term loans to finance long-term projects, hence the respective company or bank faces interest rate risk. On contrary, currency mismatch occurs if a company or bank borrows and conduct its day-to-day operation in different currencies. Currency mismatch becomes major source of problem in a currency crises when many companies and commercial banks did not hedge their foreign currency liabilities.

Currency crisis, to certain extent, is influenced by economic agents’ expectations toward monetary authority’s choice between defending domestic currency or maintaining financial system. Central bank faces policy dilemma when it deals with currency crises. It is very difficult for the central bank to increase interest rate for defending the currency, since it will hurt the financial system. Higher interest rate means higher interest burden for companies and banks, and it also increases the probability of debtors default. However, letting the currency to depreciate or devaluate easily is not a good choice either, as it puts greater burden for companies and commercial banks to pay their foreign liabilities.
If economic agents believe that the central bank will do its best to maintain existing exchange rate level, it might be possible to prevent currency crisis; or even when it occurs, the social loss can be minimized. Eichengreen, Rose, and Wyplosz (1999) showed that countries, whose central banks take last minutes steps to defend the currency by significantly reducing money growth, sometimes succeeded in defending their exchange rates. Last minutes steps might reduce speculative attacks on domestic currency, since no gains can be obtained by speculators if current exchange rate prevails. However, if the central bank is perceived to let domestic currency depreciates or devaluates, speculators will raise their demand for foreign currencies.

Banking system fragility can be detected from commercial banks’ assets-related and liabilities-related variables. “Foreign assets growth in commercial banks” and “foreign assets to total assets ratio in commercial banks”, for example, might be useful to know how vulnerable commercial banks to exchange rate exposures.

By definition, foreign assets in commercial banks are loans lent by the banks nominated in foreign currencies. Higher foreign assets growth and foreign assets to total assets ratio in commercial banks imply higher risk of exchange rate exposures faced by the banking system, since commercial banks will be more likely to hurt by debtors defaults whenever currency crisis occurs. Commercial banks risks become greater if most foreign currency debtors posses currency mismatch problems.

Meanwhile, “commercial banks’ foreign liabilities growth” and “foreign liabilities to total liabilities ratio in commercial banks” is banking system fragility’s measures from liabilities sides. Foreign liabilities in commercial banks are commercial banks borrowing in foreign currencies. The higher foreign liabilities growth and foreign liabilities to total liabilities ratio in commercial banks, the greater foreign exchange risk faced by the banks.

Other banking system fragility-related variables are “private loan to deposit ratio”, “total loan to deposit ratio”, “credit to private sector (private lending) growth”, and “total credit growth” in commercial banks. On one hand, higher value of these variables implies higher roles played by commercial banks as financial intermediaries. However, on the other hand, it also reflects greater risks faced by commercial banks if the debtors default their payment obligations.

In order to detect financial system fragilities, it is also important to notice stock market-related variables. Stock market may or may not collapse prior to currency crises, but some regularities pattern of stock exchange movement may exist. Although “Jakarta Composite Index level” is unable to predict 1997 – 1999 currency crises series in Indonesia,
other stock exchange-related variables are still included in early warning system preliminary test. The variables are “Jakarta Composite Index (JCI) yearly growth”, and “JCI monthly volatility”. Since “JCI growth” and “JCI volatility” variables monitor JCI performance in a longer period than “JCI level” variable, it is expected the earliest two variables can capture more useful information with regard to JCI’s nature.

In brief, variables for currency crisis early warning system preliminary test based on “financial system fragility” argument are: (1) Deposit Money Banks’ private loan to deposit ratio; (2) Deposit Money Banks’ total loan to deposit ratio; (3) Deposit Money Banks’ credit to private sector (private lending) growth; (4) Deposit Money Banks’ total credit growth; (5) Deposit Money Banks’ foreign liabilities growth; (6) Deposit Money Banks’ foreign assets growth; (7) Deposit Money Banks’ foreign liabilities to total liabilities ratio; and (8) Deposit Money Banks’ foreign assets to total assets ratio; (9) JCI growth; and (10) JCI volatility.

3.4 High Degree of Economic Openness

High degree of economic openness is also considered as a precondition, if not the trigger, of a currency crisis. Higher degree of economic openness reflects higher vulnerability of the an economy towards global economy exposures. Currency crises are likely to spread among countries with high degree of economic openness. Fratzcher (1998) showed that there are two possible contagion channels, through which currency crisis from one country may spread to other countries: (1) trade channel; and (2) financial channel.

Currency crises spread via trade channel phenomenon was fist explained systematically by Gerlach and Smets (1995) by their study of Finland and Sweden currency crises in 1992, and later by Fratzcher (1998). Finland and Sweden are two Scandinavian countries with tight trade linkage. Based on Gerlach and Smits, real depreciation of a country’s currency enhances the competitiveness of the respective country’s exports. This condition will affect second country’s economy, which has intensive trade relations with the first country. The second country will suffer current account deterioration, as its currency becomes less competitive to the first country’s currency. Current account deterioration in the second country will eventually result in its currency depreciation. Fratzcher added that crises may spread to countries with low degree of trade relations among themselves, as long as these countries compete in the third market.

Some variables is useful to measure degree of domestic economic openness towards trade exposures. “Current account surplus to GDP ratio”, “trade volume to GDP ratio”, and “trade balance surplus (or net export) to GDP ratio”, for instance, are variables to measure
international trade’s role in national economy. Higher value of these ratios reflect higher trade contribution to domestic economy production, and also higher degree of the respective economy openness towards trade fluctuations.

“Trade volume growth” is an absolute measure of a country’s involvement in international trade. Higher (yearly) trade volume growth implies higher involvement of a country in international trade within the respective year. Meanwhile, “trade balance surplus to trade volume ratio” measures country’s gains from international trade, with higher value of ratio reflects more benefit a country can earn from trade. Other variables can be used to measure trade’s role for international reserves accumulation in a country, such as “current account surplus to international reserves ratio” and “trade volume to international reserves ratio”. The higher the ratios, the more trade’s contribution for obtaining foreign reserves.

“REER volatility” is another variable that related to trade volume. Many research, including Reza and Rajan’s (2002), had proven that higher REER volatility reduces international trade volume, as exporters and importers are reluctant to conduct transactions in a condition where exchange rate becomes more unpredictable. Since higher REER volatility curbs trade volume, it is reasonable to think that higher REER volatility also reduces economic openness of a country.

Currency crises also spreads through financial channel. The strength and speed of crises dissemination via this channel is mainly determined by a country’s financial market integration to the world financial market, including how the respective country controls capital flows from and to its economy. The higher the degree of integration and the less capital flows restriction, the more likely crisis spreads through this channel.

It is reasonable to say, then, that financial deregulation policy applied by many developing countries to obtain foreign capitals is in fact a risky policy, as these countries becomes more vulnerable to foreign capital flows turbulences. In late 1970s and early 1980’s, for example, there were massive capital inflows to Latin American countries, which most of the funds were in foreign debts borrowed from private creditors5. Since most Latin American countries debts are nominated in foreign currency, mainly US Dollar, this condition creates greater catastrophic impacts when currency crises occurred in 1982.

Financial channel argument can also explain how a country’s macroeconomic policies may affect other countries economy and their currencies. Like in trade channel case, currency crises transmission through financial channel is a beggar-thy-neighbour phenomenon. An interest rate raise in a country, for example, boost capital inflows to the respective country,

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5 For more details of Latin American currency and debt crises, see Gibson (1996).
while causing capital outflows in other countries. Since capital outflows implies higher demand for foreign currency, other countries see depreciation or devaluation pressure to their currencies.

Degree of capital mobility and economic openness toward international exposures through financial channel can be measured by some variables, such as “financial account surplus”, “financial account surplus growth”, “foreign direct investment value”, “foreign direct investment growth”, “portfolio and other investment value”, and “portfolio and other investment growth”. Higher value of these variables reflects higher degree of capital mobility, and also higher degree of economic openness towards capital flows fluctuation. Meanwhile, “financial account surplus to GDP ratio” and “financial account surplus to international reserves ratio” measure capital flows’ role to national economy production and international reserves accumulation respectively.

In brief, variables that can be derived from “high degree of economic openness” argument for early warning system indicators preliminary test are: (1) trade balance surplus / GDP; (2) trade balance surplus / international reserves; (3) trade volume growth; (4) REER volatility; (5) trade volume / GDP; (6) trade volume / international reserves; (7) trade balance surplus / trade volume; (8) current account surplus / GDP; (9) current account surplus / international reserves; (10) financial account surplus; (11) financial account surplus growth; (12) financial account surplus / GDP; (13) financial account surplus / international reserves; (14) foreign direct investment value; (15) foreign direct investment growth; (16) portfolio and other investment value; and (17) portfolio and other investment growth.

4. Early Warning System Models

Based on their methodology, early warning system models in previous studies can be classified into two main categories: (1) leading indicators models; and (2) “discrete dependent variable” models. The following part is a brief explanation of both types of early warning system models.

4.1 Leading Indicator Models

In leading indicator models, economic variables, both individually or in a group (composite), can be used as indicators to predict currency crisis occurrence in the near future. Kaminsky-Lizondo-Reinhart’s model (1998), for instance, is a prototype of early warning system model based on individual leading indicators. The next section will describe each type of leading indicator models, along with its weaknesses and strengths.
4.1.1 Individual Leading Indicator Model

Basically, individual leading indicator model is a model that uses a pair of two binomial variables. One variable acts as dependent variable, i.e. the “currency crisis” variable itself, and the other variable acts as the leading indicator. The basic idea of this model is that the leading indicator will issue warning signal(s) prior to the onset of currency crisis.

As already explained in previous part of this thesis, the currency crisis variable will issue a warning signal of crisis (i.e. the value of 1) when exchange market pressure (EMP) is above certain critical threshold level, and issue no signal (i.e. the value of 0) when EMP is below or at the critical threshold level. The threshold level is set based on EMPs’ mean and standard deviation.

The leading indicator is also a binomial variable. It issues a signal (i.e. the value of 1) when its value is above the critical threshold level, and issues no signal (i.e. the value of 0) when the value is lower or the same as the critical threshold level. Critical threshold level of the leading indicator can be based on percentile value of its observations or on the respective indicator’s mean and standard deviation. In Kaminsky-Lizondo-Reinhart model, the threshold is set so that it will only leave 10% or 20% best observations.

To link between the “currency crisis” variable and the leading indicator, a tool of “window” is needed. The “window” is a range of time to examine whether correlation between currency crisis and the leading indicator exists, i.e. whether a signal from the leading indicator is followed or not followed by currency crisis. The window of 24 months, for instance, means 24 months range after an observation of the respective leading indicator.

It is important to remember that time period selected for the window determines performance of an early warning system. With regard to window setting, there will be trade-off between having stronger signals from indicator and obtaining the first warning signal as early as possible. Stronger signals are needed to ensure that currency crises is really likely to occur, while earlier first signal will enable policy makers and business practitioners to anticipate or even prevent the crisis. The longer the window, the higher possibility to have first warning signal earlier, but with trade-off of more false signal or noise. On contrary, the shorter the window, the more clear signals can be obtained, but it only leaves shorter time for policy makers and business practitioners to anticipate the crisis.

The main handicap of individual leading indicator model is the loss of information caused by the use of discrete value for each leading indicator. The leading indicator in usual is not a discrete variable. Treating them as discrete variables, to certain extent, means loss of information. For example, economic growth that is either 5%, 10%, or 15% higher than its
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Critical threshold level will be treated in the same manner.

Meanwhile, the main strength of individual leading indicator model lies on its ability to observe direct correlation between an indicator and currency crisis variable. Unlike econometrics models, which oftenly use pair of independent variables to explain the dependent variable (hence each independent variable’s influence to the dependent variables is also determined by other independent variables), individual leading indicator model can provide measurement for each indicator performance. Individual leading indicator model is also easier to construct and enables policy makers and business practitioners to monitor best indicators only.

4.2.2 Composite Leading Indicator Model

Composite leading indicator model is an enhancement from individual leading indicator model. A composite leading indicator is made of several individual indicators. It is expected that the composite indicator can achieve higher accuracy in mapping actual currency crises, higher efficiency (lower number of noises than correct signals), and higher probability of crisis following a signal issuance, compared to individual indicators. The main handicap of composite leading indicator model is exactly the same as the weakness of individual indicator model, i.e. the loss of information caused by the use of discrete value for the indicators.

At least, there are two methods to build a composite indicator. In general, the main difference between the two methods lies on the procedures of signal extraction from individual indicators. In the first method, which is employed by Kaminsky (1998), all signals issued by individual leading indicators are aggregated into a composite indicator. On contrary, in the second method, as used by Herrera and Garcia (1999), signals are issued by a composite indicator itself, not by individual leading indicators.

Herrera and Garcia developed a composite indicator, named as “index of macroeconomic vulnerability” (IMV) from four variables: (1) real effective exchange rate (REER); (2) real domestic credit growth (DCG); (3) ratio of broad money to international reserves (M2/Reserves); and (4) inflation. To avoid weighing issue for these variables, each variable in Herrera-Garcia model are standardized to have zero mean (_ = 0) and unit variance (_ = 1) prior to their inclusion to IMV.

In mathematical term, IMV in Herrera-Garcia model is expressed as:

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\text{IMV} = \text{REER} + \text{DCG} + \text{M2/Reserves} + ?
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Herrera-Garcia applied four different techniques to set threshold level for a signal issuance by IMV: (1) deviation of IMV from its Hodrick-Prescott trend (“DT Model”); (2) deviation of IMV from IMVs’ mean plus 1.5 of IMVs’ standard deviation (“Simple Model”); (3) deviation of IMV from its six-months moving average (“Chartist or Moving Average Model”); and (4) deviation of IMV from its ARIMA residual (“ARIMA Residual Model”). Among these four techniques, the “Simple Model” has the closest resemblance to the basic threshold level setup used in Kaminsky-Lizondo-Reinhart model.

Although the four techniques employed by Herrera and Garcia seem to offer broader options for composite indicator threshold level setup, this study uses basic threshold level as in Kaminsky-Lizondo-Reinhart’s, i.e. 20% highest level among all of observations. The techniques in Herrera-Garcia model (except the “Simple Model”) involve more complicated technical issues, while it is better for this study to provide simple composite indicator that is easier and faster to construct.

4.2 “Discrete Dependent Variable” Models

“Discrete dependent variable” models term, as used by Bussiere and Fratzcher (2002), seems to be very confusing. Leading indicator models, in fact, also use discrete variable as their dependent variable, i.e. the “currency crisis” variable. To avoid further confusion, it is important to say that the “discrete dependent variable” models in this study refers to linear probability model, probit model, and logit model (also known as logistic model).

If the dependent variable in linear probability model, probit model, or logit model has only two category of values (e.g. 0 and 1), the model is known as binomial linear probability, probit, or logit model respectively. If the model uses a dependent variable with more than two categorical values, then the model is classified as a multinomial model.

Blanco and Garber, with their study of 1980’s Mexican crisis, are considered to be the first pioneers who developed “discrete dependent variable” model for early warning system. Further development of this type of models are made either by using single data (e.g. Cumby-Wijnbergen, and Edwards) or panel data (e.g. Bilson, and Edin-Vredin)6.

Based on this approach, dependent variable is a categorical (discrete) variable, while independent variables can be categorical or numerical (continuous variable). By retaining the original value of independent variables, especially the continuous ones, the loss of information in discrete dependent variable is lesser than in leading indicators model.

6 Summary of these studies can be seen in Kaminsky, Lizondo, and Reinhart (1998).
The main handicap of discrete dependent variable model lies on its inability to determine the degree of sensitivity among its independent variables when all of these variables are used simultaneously. In other word, this model can not determine whether one indicator issue more accurate signal than others. As it is better to know each variable performance as leading indicator of currency crises, this study will not use the so-called “discrete dependent variable” model.

5. Type I and Type II Error in Early Warning System Models

There are two possible errors that can happen in an early warning system model, i.e. not issuing any signal when currency crisis occurs in upcoming months (also called as type I error), or giving signal when currency crisis does not occurs in upcoming months (noise or type II error). From decision makers perspective, type I error causes bigger social loss than type II error.

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Basic set up for critical threshold of independent variable signals plays very important role in determining whether type I or type II error will likely to occur. The lower the critical threshold level, the higher probability of type II error occurrence. On contrary, the higher the critical threshold level, the higher probability of type I error to occur.

Although the social loss caused by type II error is lower than by type I error, it does not mean that the model should use the as-low-as-possible threshold level. The higher the probability of type II error caused by lower level of critical threshold, the more inefficient the early warning system. In this circumstance, the early warning system is no longer be able to differentiate between normal and precrisis condition.

6. Previous Research Results

Findings from previous research are also taken as references for this study, where four among them contribute the most. The four studies are: (1) Kaminsky-Lizondo-Reinhart’s
individual leading indicator model; (2) Glick-Hutchison’s currency crisis and banking crisis joint-models; (3) Bussiere-Fratzcher’s binomial and multinomial logit models; and (4) Herrera-Garcia’s composite indicator model. Although this study does not use “discrete dependent variable” model, Glick-Hutchison’s and Bussiere-Fratzcher’s findings are still interesting to discuss as comparison to this study findings.

Before exposing findings from the four above mentioned studies, it is better to discuss the definition of “currency crisis” used in each research. Kaminsky, Lizondo, and Reinhart (1998) defined currency crisis as a condition where exchange market pressure (EMP) index lies above EMPs’ mean plus three times of EMPs’ standard deviation. Glick and Hutchison (2000) referred currency crisis as a movement of EMP (in their term: index of currency pressure) above EMPs’ mean plus two times of EMPs’ standard deviation. Bussiere and Fratzcher used the same threshold level of EMPs index as in Glick-Hutchison’s model to define currency crises. Herrera and Garcia set mean plus 1.5 times standard deviation of EMPs index (in their term: index of speculative pressure) as threshold level of currency crises. In both definitions, higher EMP (in positive number) means higher tendency for a currency to undergo devaluation or depreciation.

In Kaminsky-Lizondo-Reinhart’s and Glick-Hutchison’s model, EMP is defined as weighted average value of nominal exchange rate and international reserves monthly volatility, with higher weight is given to component with lower volatility. Meanwhile, Glick and Hutchison, in their panel data model, defined index of currency pressure as weighted average of monthly real exchange rate and monthly percentage of reserve losses. The weights are inversely related to variance of each component changes over the sample for each country. By using real exchange rate, Glick and Hutchison expected that biases in currency pressure measurement caused by occasionally hyperinflation can be avoided.

In Herrera-Garcia’s model (1999), index of speculative pressure components comprises monthly percentage change of nominal exchange rate, interest rate, and international reserves. These components are given the same weight, and normalized to have zero mean (\(\mu=0\)) and unit variance (\(\sigma=1\)).

Bussiere-Fratzcher’s model (2002) defines EMP as weighted average value of real exchange rate monthly volatility, monthly real interest rate change, and international reserves monthly volatility. Bussiere-Fratzcher model also gives higher weight to component with lower volatility. The use of real term for exchange rate and interest rate volatility in Bussiere-Fratzcher model is to deal with different inflation rates among countries selected as samples.

EMP in Bussiere-Fratzcher model is expressed as:
As their findings, Kaminsky-Lizondo-Reinhart found that several macroeconomic variables are working well as individual leading indicators of currency crisis. The indicators are (1) national output (GDP); (2) exports; (3) real effective exchange rate; (4) stock index; and (5) ratio of broad money to international reserves. These indicators issue at least one signal 24 months prior to a crisis.

Herrera and Garcia showed that the IMV worked well as a composite leading indicator in their 24-months-window early warning system models. Among the four different models by its threshold setup technique, the “Simple Model” perform best in almost all of sample countiers, except in Argentina and Brazil. The “Chartist Model” is the best model for Argentina, while the “DT Model” is best for Brazil. With regard to error types of signals issued, Herrera-Garcia study found higher numbers of type I error and lower numbers of type II error in their models than in Kaminsky-Lizondo-Reinhart’s.

Bussiere and Fratzcher pointed out that their multinomial logit model (with three categories of dependent variable) could predict currency crisis probability more efficient than ordinary binomial logit model. Variables that worked well in Bussiere-Fratzheimer study are: (1) real exchange rate misalignment from its trend; (2) lending boom; (3) ratio of short term debt to international reserves; (4) ratio of current account to GDP; (5) financial contagion; and (6) economic growth. Bussiere and Fratzcher also found out that 20% was the optimum threshold value for these variables to predict the probability of crisis. By applying the 20% threshold level, they obtain 12 months as the optimum horizon (window) for their system.

Glick and Hutchison concluded that in general, banking crisis is a good indicator of future currency crisis, but not the vice versa. Their other finding is that the simultaneous or almost simultaneous banking and currency crises (the twin crises) phenomenon are more often to occur in developing and emerging countries than in developed countries. They also found out that strong causality, joint-feedback relations between currency crises and banking crises only existed in financially-liberalized emerging countries.

Glick and Hutchison suggested further that monetary authority should take measures to prevent banking crises, since it can reduce the possibility of currency crises occurrence. On the other hand, currency crisis prevention measures (especially in emerging countries) can also reduce the possibility of banking crisis occurrence. As long as central bank has sufficient foreign reserves to defend the currency, Glick and Hutchison suggestion may
work well. However, in extreme twin crises cases, where central bank suffers lack of foreign reserves, “policy dilemma” becomes the rule. Pouring more liquid money to prevent banking system collapse will result in higher pressure for domestic currency to depreciate. On contrary, defending the currency by raising interest rate will hurt commercial banks.

7. Models Specification
7.1 Currency Crisis Definition

Currency crisis definition in this study refers to Bussiere-Fratzcher’s definition. Due to the single country nature of this study (not a panel data study), two modifications are made to the original EMP equation in Bussiere-Fratzcher’s model. The first modification is to replace real exchange rate and interest rate with their nominal values, while the second is to make new weighing method for EMP components.

Weighing method for the three components of EMP in this study is based on their standard deviation. Higher weight is given to component with higher standard deviation, based on consideration that variable with higher standard deviation generates stronger pressure on exchange rate than the lower ones. The procedure of weighing is defined as follows:

First, determine the ratio of weights among EMP components by using standard deviation of each component \(r_i; i = 1, 2, 3\). Component with lowest standard deviation is set to be the benchmark category with the value of 1.

\[
\frac{r_1}{r_2} : r_3 = \frac{stddev(X_1)}{stddev(X_2)} : \frac{stddev(X_3)}{stddev(X_3)}
\]

where

\[
stddev(X_1) > stddev(X_2) > stddev(X_3)
\]

and

\[
r_3 = 1
\]

Second, determine the weight for each component by dividing each value of \(r_1, r_2, r_3\) with total sum of \(r_1, r_2,\) and \(r_3\).

\[
\omega_1 : \omega_2 : \omega_3 = \frac{\frac{r_1}{R}}{R} : \frac{\frac{r_2}{R}}{R} : \frac{\frac{r_3}{R}}{R}
\]

where
$R = r_1 + r_2 + r_3$

Meanwhile, currency crisis in this study is defined as any condition where EMP of an observation is higher than EMPs’ mean plus one times EMPs’ standard deviation. Currency crisis definitions used by Kaminsky-Lizondo-Reinhart’s, Glick-Hutchison’s, Herrera-Garcia’s, and Bussiere-Fratzcher’s models are not suitable for the case of Indonesia. These definitions of currency crisis are unable to include the Rupiah’s 1986 devaluation, due to their very high threshold level of crisis.

In mathematical term, currency crisis in this study is defined as:

$$CC = \begin{cases} 
1 & \text{if } EMP_i > \overline{EMP} + SD(EMP) \\
0 & \text{if others} 
\end{cases}$$

7.2 Individual Leading Indicator Model Specification

Individual leading indicator model in this study uses a threshold level which will leave 20% best observations of a variable. Whenever an observation is higher than the threshold level, a warning signal of currency crisis will be issued. Four below categories are used as building blocks to construct ratios for indicators performance measurement:

1) Correct signal (labelled as “A”)

A correct signal is a signal that is followed by a currency crisis within 24 months period after its issuance.

2) Type II error (labelled as “B”)

A type II error occurs when an indicator issue a signal, but not followed by any currency crisis within the next 24 months period.

3) Type I error (labelled as “C”)

A type I error occurs when an indicator does not issue any signal within 24 months period prior to an actual currency crisis.

4) Correct time when an indicator does not issue any signal (“D”)

When an observation shows that an indicator does not issue any signal and the absence of signal is not followed by any currency crisis within the next 24 months period, the observation falls into “D” category.
Three following ratios are used to determine best indicators to be selected in individual leading indicator model for early warning system\textsuperscript{7}:

1) Percentage of Correctly Called Crises

Percentage of correctly called crises is measured as a ratio between numbers of correctly called crises to the number of actual currency crises. The higher this ratio, the higher leading indicator's ability to map actual currency crises occurrence. A good indicator based on this criterion should at least issues one signal within the 24-months window prior to the crises. In mathematical term, percentage of correctly called crisis is expressed as follows:

\[
\text{Percentage of correctly called crises} = \frac{\text{number of correctly called crises}}{\text{number of actual crises}}
\]

2) Adjusted Noise to Signal Ratio

Adjusted noise to signal ratio is a measure of indicator's efficiency in issuing warning signals. Higher value of this ratio implies lower efficiency of an indicator in predicting currency crises. As a rule of thumb, adjusted noise to signal ratio which is lower than or equal to 100\% shows that the respective indicator is still efficient. On contrary, an indicator with higher than 100\% adjusted noise to signal ratio is considered as not efficient. In mathematical term, adjusted noise to signal ratio is expressed as:

\[
\text{Adjusted noise to signal ratio} = \frac{B/(B + D)}{A/(A + C)}
\]

3) Probability of Crisis Following a Signal Issuance

The third criterion used to determine best indicators is the probability of crisis following a signal issuance. The higher the probability, the better an indicator performance will be. In mathematical term, probability of crisis following a signal issuance is expressed as:

\[
\text{Probability of crisis following a signal issuance} = \frac{A}{(A + B)}
\]

In this study, to be considered as one among the bests, an individual leading indicator should:

\textsuperscript{7} These criteria is taken from Kaminsky, Lizondo, and Reinhart (1998).
1) Be able to map at least 70% of all actual currency crises in Indonesia. It means the indicator should issue at least one signal within 24 months period prior to an actual crisis. In other words, the respective indicator should have equal to or higher than 70% accuracy level.

2) Be efficient, which means that the adjusted noise to signal ratio should be lesser than or equal to 100%.

3) Have greater than or equals to 50% probability of crisis occurrence following its signal issuance.

### 7.3 Composite Leading Indicator Model Specification

Composite leading indicators in this study are constructed from best individual leading indicators. A composite indicator is made by summing up its standardized individual indicator components. A signal will be issued by a composite indicator whenever an observation passes critical threshold level, a value that leaves only 20% highest observations. The three above mentioned criteria for individual indicators are also used to measure composite leading indicators performance.

### 7.4 Research Procedures

The procedures of this research can be described as follows:

1) **Identifying currency crisis occurrence**, comprises:

   a. Calculating monthly exchange rate volatilities, interest rate changes, and international reserves volatilities as components of EMPs

   b. Measuring standard deviation of each EMPs component and creates ratios among the three standard deviations, with the lowest standard deviation set as the benchmark and has the value of 1.

   c. Summing up the ratios and divide each ratio to total sum as the weight for each component

   d. Monthly EMP is measured by summing up all of its weighted components

   e. Calculate EMPs’ mean and standard deviation for crisis critical threshold. The threshold is set as EMPs mean plus one of EMPs’ standard deviation.

   f. If any EMP observation is greater than the critical threshold, a currency crisis occurs
2) **Identifying signals from indicator**, comprises:
   a. Normalizing each observation of an indicator, by subtracting an observation value from indicator’s mean, and dividing by indicator’s standard deviation
   b. Sorting the normalized observation values, from the highest to the lowest
   c. Selecting a threshold level that will leave 20% best observation of the respective indicator.
   d. If any observation is greater than the critical threshold level, the indicator will issue a warning signal of currency crisis within upcoming 24-months.

3) **Measuring indicator’s performance**, comprises:
   a. Comparing currency crisis and indicator’s warning signal issuance data for each variables examined as candidates for leading indicators
   b. A correctly called crisis is obtained by **looking backward** an indicator’s signal issuance data within 24-months period prior to a crisis, whether the indicator issue at least one signal or not. If the answer is yes, then the value of correctly called crisis equals to 1, otherwise 0. Numbers of correctly called crises is the sum of correctly called cases. Meanwhile, percentage of correctly called crises is calculated by dividing numbers of correctly called crisis to numbers of actual currency crises.
   c. Correct signal (A), type II error (B), type I error (C), and correct event of no signal issuance (D) is obtained by **looking forward** currency crises data. If a crisis occurs within 24-months period following a signal issuance, then it should be “A”, otherwise “B”. If an indicator does not issue any signal, but at least one crisis does occur within the 24-months forward period, then it should be “C”, otherwise “D”.
   d. From the previous step, “Adjusted Noise to Signal Ratio” and “Probability of Crisis Following a Signal Issuance” can be calculated.

4) **Selecting Best Indicators**
   a. Selecting ten best indicators (or more) based on percentage of correctly called crises criterion.
   b. Selecting ten best indicators based on adjusted noise to signal criterion.
   c. Selecting ten best indicators based on probability of crisis following a signal issuance.
   d. Selecting best indicators in overall criteria, which have percentage of correctly called crises equals to or greater than 70%, less than or equals to 100% adjusted noise to signal ratio, and equals to or higher than 50% probability of crisis following a signal issuance.
7.5 Data Source and Software Used

Data range for this study is from January 1981 to December 2002, except for JCI (from April 1983) and balance of payment items (from March 1981). The data are taken from the IMF’s International Financial Statistics (IFS) and Bloomberg’s Economic Statistics (ECST). Monthly data of GDP, current account and financial account surplus are obtained by linearly interpolating their quarterly values. GDP data is in its index value, with 1996 is set as the base year.

Matlab version 6.0. Release 12 and Microsoft Excel 2000 are software used to construct early warning system in this study. The two software are not used complementary (except in tabulation of results which is done in Excel), as the models in this study are deliberately built by using each software separately. The Matlab program of early warning system is built to provide ready-to-use tool for examining each indicator faster. The Matlab version is more adjustable than the Excel version, since one can change the window and threshold level of early warning system easier. However, the Excel program is still used as the benchmark to control the Matlab program from making errors. Both programs use the if-then logic arguments as their building bricks.

8. Results and Analysis

8.1 Actual Currency Crises Cases

As already explained previously, currency crisis in this study is defined as a condition where EMP passes EMPs’ mean plus one times EMPs’ standard deviation. Based on this definition, the EMPs’ threshold level for currency crisis occurrence is 4.9%. Any condition
where EMP passes its threshold level is considered as a currency crisis. The following table illustrates Rupiah exchange market pressure movement from February 1983 to December 2002.

The weighing for EMP components are set as: 0.4 for exchange rate volatility; 0.3 for international reserves volatility; and 0.3 for money market interest rate monthly change. Hence, total value of weights equals to 1.0. The highest weight was given to exchange rate volatility as it has the greatest standard deviation among all EMP components. The actual currency crises occurrence in Indonesia, along with EMP and its components values are depicted in the following table:

<table>
<thead>
<tr>
<th>Date of Crisis</th>
<th>Exchange Market Pressure</th>
<th>Exchange Rate Volatility (weight = 0.4)</th>
<th>Interest Rate Volatility (weight = 0.3)</th>
<th>International Reserves Volatility (weight = 0.3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1983</td>
<td>10.8%</td>
<td>0.3%</td>
<td>1.4%-33.8%</td>
<td></td>
</tr>
<tr>
<td>April 1983</td>
<td>10.2%</td>
<td>38.1%</td>
<td>-3.0%</td>
<td>19.0%</td>
</tr>
<tr>
<td>September 1986</td>
<td>14.2%</td>
<td>27.0%</td>
<td>0.6%</td>
<td>-7.0%</td>
</tr>
<tr>
<td>October 1986</td>
<td>6.7%</td>
<td>13.7%</td>
<td>-0.3%</td>
<td>-2.4%</td>
</tr>
<tr>
<td>August 1997</td>
<td>19.0%</td>
<td>11.2%</td>
<td>49.2%</td>
<td>-4.7%</td>
</tr>
<tr>
<td>October 1997</td>
<td>7.9%</td>
<td>18.4%</td>
<td>-12.3%</td>
<td>-9.6%</td>
</tr>
<tr>
<td>December 1997</td>
<td>20.0%</td>
<td>40.6%</td>
<td>-1.5%</td>
<td>-8.2%</td>
</tr>
<tr>
<td>January 19984</td>
<td>4.0%</td>
<td>96.8%</td>
<td>16.5%</td>
<td>9.4%</td>
</tr>
<tr>
<td>May 1998</td>
<td>6.6%</td>
<td>24.5%</td>
<td>-7.3%</td>
<td>7.6%</td>
</tr>
<tr>
<td>June 1998</td>
<td>16.8%</td>
<td>36.8%</td>
<td>1.1%</td>
<td>-1.2%</td>
</tr>
<tr>
<td>January 1999</td>
<td>5.2%</td>
<td>12.4%</td>
<td>4.5%</td>
<td>4.6%</td>
</tr>
</tbody>
</table>

EMPs historical data shows that eleven currency crises had occured in Indonesia during February 1983 and December 2002. The March and April 1983 crises lead to “1983 Rupiah Devaluation”, as the government officially announced that the exchange rate was changed to IDR 968.6 / USD, from previously IDR 699.1 / USD in February 1983. The second devaluation within this period occured in October 1986, after Rupiah exchange market pressure passed its threshold level in September and October 1986.

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pressure reached 44.0% and Rupiah was dropped to IDR 9,662.5/USD from IDR 4,908.8/USD in December 1997. The “1997-1999” crises series also had political consequences as it became one among critical factors that forced Soeharto to resign from his presidency in May 1998.

8.2 Models Examination Results
8.2.1 Individual Leading Indicators

Examination result of the 65 variables in this study shows that only few variables are reliable as individual leading indicators for early warning system. In general, even more limited numbers of indicators can satisfy all of the three criteria. For example, some variables can accurately map all of actual currency crises, but these variables are not efficient by often issuing unnecessary signals. On contrary, other variables are very efficient, but missed a lot numbers of actual crises.

Result of indicators examination by using the overall three criteria shows that only five variables are eligible to be selected as core indicators in individual leading indicator model. The indicators are: (1) Rupiah REER misalignment over its trend value; (2) foreign assets growth in Domestic Money Banks; (3) financial account surplus; (4) M0 growth; and (5) ratio of financial account surplus to GDP.

These indicators have higher than 70% percent accuracy in mapping actual currency crises, high efficiency level (reflected by their adjusted noise to signal ratio, which are lower than 100%), and high probability of currency crisis following a signal issuance (higher than 50%). Among the core individual leading indicators for early warning system, only “REER misalignment over its trend” and “Deposit Money Banks foreign assets growth” can predict all of actual currency crises occurrence with 100% level of accuracy.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Percentage of Correctly Called Crises</th>
<th>Adjusted Noise Signal Ratio</th>
<th>Probability of Crisis Following A Signal Issuance</th>
</tr>
</thead>
<tbody>
<tr>
<td>REER Misalignment over Trend</td>
<td>100,0%</td>
<td>11,7%</td>
<td>80,0%</td>
</tr>
<tr>
<td>DMBs Foreign Assets Growth</td>
<td>100,0%</td>
<td>30,0%</td>
<td>61,0%</td>
</tr>
<tr>
<td>Financial Account Surplus</td>
<td>90,9%</td>
<td>32,4%</td>
<td>59,2%</td>
</tr>
<tr>
<td>M0 Growth</td>
<td>72,7%</td>
<td>32,4%</td>
<td>59,2%</td>
</tr>
<tr>
<td>Financial Account Surplus / GDP</td>
<td>72,7%</td>
<td>41,7%</td>
<td>52,9%</td>
</tr>
</tbody>
</table>
8.2.2 Composite Leading Indicators

The composite leading indicators in this study are made from combinations of the overall-criteria five best individual leading indicators. A restriction is imposed so that “financial account surplus” variable will not meet “ratio of financial account surplus to GDP” variable in the same combination. Overall, 18 possible combinations of composite indicators can be made. From all of these combinations, 9 combinations are made of two elements, 7 combinations of three elements, and only 2 combinations of four elements. The restriction causes combination made of five elements ineligible for composite indicators.

Examination results show that 17 out of 18 composite leading indicators can meet the overall criteria. The only composite indicator with poor result is “XY”, a combination of “financial account surplus” and “M0 growth” variables. The seventeen composite indicators perform better than the five best individual leading indicator, mainly by their higher effi-

<table>
<thead>
<tr>
<th>Composite Indicator</th>
<th>Percentage of Correctly Called Crises</th>
<th>Adjusted Noise Signal Ratio</th>
<th>Probability of Crisis Following A Signal Issuance</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW</td>
<td>100.0%</td>
<td>9.1%</td>
<td>83.7%</td>
</tr>
<tr>
<td>VWY</td>
<td>100.0%</td>
<td>11.7%</td>
<td>80.0%</td>
</tr>
<tr>
<td>VWZ</td>
<td>100.0%</td>
<td>13.8%</td>
<td>77.3%</td>
</tr>
<tr>
<td>VWYZ</td>
<td>100.0%</td>
<td>15.2%</td>
<td>75.6%</td>
</tr>
<tr>
<td>VZ</td>
<td>100.0%</td>
<td>17.6%</td>
<td>72.7%</td>
</tr>
<tr>
<td>VWX</td>
<td>100.0%</td>
<td>18.2%</td>
<td>72.1%</td>
</tr>
<tr>
<td>WZ</td>
<td>100.0%</td>
<td>26.1%</td>
<td>64.3%</td>
</tr>
<tr>
<td>VY</td>
<td>100.0%</td>
<td>26.4%</td>
<td>64.0%</td>
</tr>
<tr>
<td>VYZ</td>
<td>100.0%</td>
<td>32.4%</td>
<td>59.2%</td>
</tr>
<tr>
<td>WX</td>
<td>90.9%</td>
<td>17.6%</td>
<td>72.7%</td>
</tr>
<tr>
<td>YZ</td>
<td>90.9%</td>
<td>40.0%</td>
<td>54.0%</td>
</tr>
<tr>
<td>VWXY</td>
<td>81.8%</td>
<td>13.4%</td>
<td>77.8%</td>
</tr>
<tr>
<td>WXY</td>
<td>81.8%</td>
<td>20.5%</td>
<td>69.6%</td>
</tr>
<tr>
<td>VX</td>
<td>81.8%</td>
<td>21.0%</td>
<td>69.0%</td>
</tr>
<tr>
<td>WYZ</td>
<td>81.8%</td>
<td>24.2%</td>
<td>66.0%</td>
</tr>
<tr>
<td>VXY</td>
<td>81.8%</td>
<td>25.7%</td>
<td>64.6%</td>
</tr>
<tr>
<td>WY</td>
<td>81.8%</td>
<td>29.1%</td>
<td>61.7%</td>
</tr>
</tbody>
</table>

Note:

V        REER Misalignment over Trend
W        DMBs Foreign Assets Growth
X        Financial Account Surplus
Y        M0 Growth
Z        Financial Account/GDP
ciency level and higher probability of crisis following a signal issuance. These composite indicators can also map actual currency crises occurrence with higher than 80% level of accuracy, and even nine among them reach 100%.

The table shows that the nine best composite leading indicators contain either “Rupiah REER misalignment over its trend value” or “Deposit Money Banks’ foreign assets growth” variables as its element.

8.3 Analysis

As already shown previously, “Rupiah REER misalignment over its trend value”, “Deposit Money Banks’ foreign assets growth”, “financial account surplus”, “base money growth”, and “ratio of financial account surplus to GDP” are best individual leading indicators. From these individual indicators, 17 best composite leading indicators can also be constructed. The following part is a thorough analysis about the nature and behaviour of the these individual indicators with regard to Indonesian economy historical data.

8.3.1 REER Misalignment over Its Trend Value

“Rupiah REER misalignment over its trend value” is the best of the best individual leading indicators. Combined with “Deposit Money Banks’ foreign assets growth” variable, this variable produce “VW” composite indicator, which is the best among all composite indicators. Rupiah REER movement along with its quadratic trend and misalignment since January 1981 until December 2002 are depicted in the following graph:
Excellent performance of “Rupiah misalignment over its trend value” as a leading indicator of currency crises can be seen from its historical data. Prior to devaluation against US Dollar in April 1983 and September 1986, Rupiah was overvalued against its trend. Before the great crises series started in August 1997, Rupiah was also overvalued against its trend, and even reached the highest level of misalignment in April 1997 at 28.23%.

Based on theory, real overvaluation of a currency against its trend is one among possible causes of currency crisis. Real overvaluation leads to trade balance deterioration, hence reduces foreign reserves accrued from international trade. The condition depletes foreign reserves owned by central bank, and weaken central bank’s ability to defend current exchange rate level when attacks toward domestic currency take place. To examine trade balance deterioration, it is better to use \textit{trade balance surplus growth} rather than trade balance surplus itself, as the previous is a flow variable.

Although trade balance surplus growth is not a good individual leading indicator in this study, due to its lower than 50% probability of crisis following a signal issuance, historical data of this variable supports the claim that currency real overvaluation did happened prior to all currency crises occurrence in Indonesia. Prior to the onset of 1997 – 1999 currency crises series, Indonesia suffered trade balance deterioration in all months of 1995 and several times in 1996 and 1997, as reflected in its negative values of trade balance surplus growth.

As shown in the following picture, to obtain 20% best observation of “Rupiah REER misalignment over its trend value” variable, 15.1% is selected as the threshold level. Any
Rupiah REER misalignment over its trend that is greater than 15.1% will produce a warning signal of currency crisis.

“Rupiah REER misalignment over its trend value” indicator can issue a signal as early as 24 months prior to a crisis, as in September 1997 crisis. In average, “Rupiah REER misalignment over its trend value” indicator can issue a warning signal at least in 21 months prior to a currency crisis. However, the indicator does not consistently issue warning signals in every months within the window, as in 1983 and 1986 Rupiah devaluation cases. It only issues nine warning signals prior to April 1983 devaluation, and seven signals prior to October 1986 devaluation.

8.3.2 Deposit Money Banks’ Foreign Assets Growth

Deposit Money Banks’ foreign assets are loans in foreign currency lent by Deposit Money Banks to the debtors. These loans are used by borrowers to meet their payment obligations in foreign currencies, such as for exports and imports financing. Some exports – imports activities require exporters and importers to prepay the costs of warehousing, shipments, and insurances prior to the acceptance of payments or goods.

Although foreign assets are one source of revenues for banks, they also contain risks. Foreign assets, especially unhedged ones, are very vulnerable to foreign exchange exposures. If the debtors earn their revenues in domestic currency, unanticipated exchange rate turbulences may cause them to default their obligations. This condition will result in banking system crisis. In brief, excessive foreign assets growth in Deposit Money Banks should be
awared as it becomes an indication of increasing banking system fragility and vulnerability toward exchange rate exposures.

It is interesting to note that all of currency crises in Indonesia were preceded by or occurred at the same time with the banking crises. In a condition where currency and banking system crises occur in the same time, central bank will hesitate to increase interest rate to defend its exchange rate target level. An interest rate increase will hurt the banking system, as Deposit Money Banks have to pay higher deposits interest and face greater risks of obligors default. Hence, although foreign assets growth in Deposit Money Banks was not the trigger of a currency crises occurrence, it did worsen the crises.

In testing “Deposit Money Banks’ (DMBs) foreign assets growth” performance as a leading indicator, the variable is expressed in million US Dollar. This treatment is made in order to avoid bias caused by exchange rate turbulence. If the variable is expressed in Rupiah, foreign assets growth will rocket during the crisis period, while the real value expressed in US Dollar grow more moderately.

Based on examination results, “DMBs foreign assets growth” is in the second place among all best individual leading indicators. Together with “Rupiah REER misalignment over its trend value”, this variable construct “VW”, the best composite leading indicator.

From its historical trend, “DMBs foreign assets growth” indicator issued at least one signal prior to all currency crises occured in Indonesia. The threshold level for a signal issuance of “DMBs foreign assets growth” is 18.0%. “DMBs foreign assets growth” indicator was able to issue a warning signal as early as 24 months prior to 1983 and 1986 Rupiah devaluations.
In average, “DMBs foreign assets growth” indicator can issue at least a warning signal in 21 months prior to a currency crisis. Nevertheless, “DMB foreign assets growth” indicator did not consistently issuing signals in every months within the 24-months window. Prior to the onset of currency crises series in August 1997, the earliest signal was issued in November 1995. The signals became more frequent within seven-months prior to August 1997.

8.3.3 Financial Account Surplus

“Financial account surplus” is the third best individual leading indicator. Combined with “Rupiah REER misalignment over its trend value” and “DMBs’ foreign assets growth” variables, this variable construct “VWX”, the sixth best composite indicator. “Financial account surplus” indicator can map 90.9% of all actual currency crises, or ten cases from all of eleven actual cases. The only crisis missed by this indicator is the September 1986 crisis.

It is a very interesting phenomenon to recall that prior to the currency crises series in 1997 - 1999, financial account surplus was going significantly higher than in normal times. In every months from March 1995 to February 1996 (except in September and October 1985), financial account surplus grew by more than twice from its previous year values. Even in June 1995, financial account surplus grew by 1872% from its value in June 1994.

The components that contributed most to the abrupt increase of financial account surplus was portfolio and other short-term investment, although foreign direct investment also saw a significant raise during this period. However, “portfolio and other investment” variable itself is less adequate to be a good individual leading indicator, as probability of crises following its signal issuance is lower than 50%. 

![Graph 7. Financial Account Surplus Components (USD Bn)](image-url)
Compared to foreign direct investment which is relatively more permanent in nature, portfolio and other short-term investment is very volatile as investors can relocate their funds in any countries faster. Higher portfolio and other short-term investment growth also means higher vulnerability of an economy to foreign capital exposures, since the funds can easily evaporate from the respective economy. Capital flight of portfolio and other short-term funds worsen a currency crisis, as it raises demand for foreign currency in the exchange market.

Based on its historical data, “financial account surplus” indicator can issue a warning signal as early as 24 months prior to a currency crisis in 1997-1999 currency crises series. In August 1995, for example, this indicator had issued a signal prior to the onset of currency crises series in August 1997. In average, “financial account surplus” indicator can issue a warning signal in 12 months prior to a currency crisis.

Nevertheless, “financial account surplus” indicator had failed to account the occurrence of September 1986 crises, as it issued no signal within the 24-months window. The signal was issued in September 1986, hence the indicator managed to catch the October 1986 devaluation but missed the September crises. The indicator also did not show consistency in issuing signal in every months within the window for the 1983 and 1986 currency crises.

8.3.4 Base Money Growth

Base money (M0) is one among instruments used by central bank to conduct monetary policy. To conduct a monetary expansion policy, for example, central banks can increase
the number of base money by conducting open market operation or lowering reserves requirement for commercial banks. Base money in Indonesia comprises currency in circulation, and all of commercial banks’ and private sector’s demand deposits held by Bank Indonesia. Currency in circulation itself consists of currency and cash in vault held by commercial banks.

As already explained previously, excessive monetary policy expansion is a possible cause of currency crises. Excess supply of money causes interest rate decline, which in turn leads to capital outflows. Massive capital outflows will push domestic currency to depreciate. Currency crisis occurs whenever central bank does not have sufficient foreign reserves to defend the existing exchange rate level.

In this study, base money growth is the fourth best individual leading indicator. This indicator, however, was failed to account three from all of eleven actual currency crises. The missing ones were February 1983, September 1986, and October 1986 crises. These crises, then, were not caused by excessive monetary policy expansion, but by Rupiah REER overvaluation over its trend and extraordinary high foreign assets growth in commercial banks.

“Base money growth” indicator can issue a signal as early as 24 months prior to a currency crises. For example, a signal was issued in January 1997 prior to January 1999 crisis. This indicator, however, can not issue consistent signals within the 24-months window in all of its correctly called crises. In average, “base money growth” indicator can issue at least a warning signal in 16 months prior to a currency crisis.
8.3.5 Financial Account Surplus to GDP Ratio

“Financial account surplus to GDP ratio” variable measures national economy dependency on foreign capital inflows. The higher the ratio, the greater foreign capital contribution in national economic production. Since the biggest share of financial inflows to Indonesia is the portfolio and other short-term investment, which are more easy to relocate than foreign direct investment, higher financial account surplus reflects greater risk of financial system collapse. As already explained previously, capital flight of portfolio and other short-term investment funds can worsen an ongoing currency crises.

“Financial account surplus to GDP ratio” is the fifth best individual leading indicator. The main handicap of this indicator lies on its inability to map three actual currency crises in Indonesia, i.e. the February and March 1983 crises, and also the September 1986 crisis. The following table illustrates this ratio historical movement, along with its threshold level to issue warning signals of an upcoming currency crisis.

<table>
<thead>
<tr>
<th>Year</th>
<th>Financial Account Surplus to GDP Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>10 Persen</td>
</tr>
<tr>
<td>1984</td>
<td>-20 Persen</td>
</tr>
<tr>
<td>1987</td>
<td>-50 Persen</td>
</tr>
<tr>
<td>1990</td>
<td>-80 Persen</td>
</tr>
</tbody>
</table>

Graph 10. Financial Account Surplus / GDP and Its Signal Threshold

“Financial account surplus to GDP ratio” can issue a warning signal as early as 24 months prior to a currency crises. Prior to August 1997 crisis, the indicator had already issued a warning signal in August 1995. The more remarkable fact is that the indicator consistently issues signals in every months within the 24-months window prior to August 1997. In other crises, however, this indicator does not show consistency of its signal issuance. “Financial account surplus to GDP ratio” in average at least can issue a warning signal in 18 months prior to a crisis.
9. Comparison to Previous Studies

There are many differences between the results obtained in this study with Kaminsky-Lizondo-Reinhart’s (1998), Bussiere-Fratzcher’s (2002), Herrera-Garcia’s (1999), and Glick-Hutchison’s (2000) results. The main difference lies on the best variables selected for early warning system. The best individual and composite indicators in this study are totally different from best variables used in the four previous studies.

There are several possible causes of the differences:

First, this study uses Indonesia’s data only, while the four studies use panel data. Bussiere and Fratzcher, for instance, use 32 emerging market countries as samples. Panel data studies cannot capture the nature of country-specific variables, since panel data is designed to capture general behaviour of variables in many countries.

Second, different methodology used in this study and in the four previous studies. The difference lies on: (1) the type of model (leading indicator model versus “discrete dependent variable” model); (2) time period of the window; (3) threshold level setting (for currency crisis and indicator’s signal issuance); or (4) criteria to measure performance and determine best variables.

Nevertheless, this study provides new evidence to support Glick-Hutchison’s results. The selection of “Deposit Money Banks’ foreign assets growth” as one among best individual leading indicators is a proof that financial system (mainly banking system fragility) is a precondition of all currency crises so-far had occurred in Indonesia. This finding strengthen Glick and Hutchison’s claim that in emerging markets, banking crises tend to occur at the same time with currency crises.

10. Concluding Remarks
10.1. Conclusion

In brief, several conclusions can be made from this study:

First, composite leading indicator model should be used as the core model for early warning system in Indonesia, since it is better than the individual indicator model. Nine from seventeen best overall-criteria composite indicators have 100% accuracy in mapping all of actual crises in Indonesia, while only two from five all-criteria best individual indicators can predict all of ex-post currency crises correctly. The composite leading indicator model is also far more better than the individual model as the composite indicators are more efficient in issuing warning signals and have higher probability of crisis following a signal issuance.
Second, two variables are considered as robust variables both in individual and composite leading indicator models. The variables are “Rupiah REER misalignment over its trend value” and “Deposit Money Banks’ foreign assets growth”, with the previous have better performance in its efficiency and higher probability of crisis occurrence following a signal than the later. Direct combination of these two variable is the overall-criteria best composite indicator, which have better performance than its elements.

Third, best individual and composite indicators in some cases can issue a warning signal in 24 months prior to a crisis occurrence. In average, best individual and composite indicators can issue a warning signal at least one year prior to a crisis. The time horizon of warning signal issuance by these indicators is sufficient to enable policy makers and business practitioners to anticipate the possible upcoming crisis.

Fourth, real misalignment of Rupiah over its trend value is a possible cause of currency crises occurrence in Indonesia. Real overvaluation of Rupiah leads to lower competitiveness of Indonesian exports, hence deteriorates trade balance, and in turn results in higher pressure for Rupiah to depreciate. This claim is also supported by historical data of trade balance surplus growth, which shows that trade balance tends to get worsen prior to a currency crisis occurrence.

Fifth, all of actual currency crises in Indonesia were preceded by excessive foreign assets growth in Deposit Money Banks. Excessive foreign assets growth puts banking system in a very fragile condition toward exchange rate exposures, hence it can worsen an ongoing currency crisis. This fact supports Glick and Hutchison’s findings that in emerging countries currency crises tend to occur at the same time with banking system crises.

10.2 Weakness of Study

In general, some weaknesses of this study are inherent with the handicaps of leading indicator model. Leading indicator model tends to create great loss of information since it forces all variables selected as indicators to have binomial values, although the respective variable might be a continuous one. Leading indicators model also cannot differentiate crisis and recovery period from tranquil period. The dependent variable can only identify precrisis and non-precrisis times, where the non-precrises category comprises both crisis, recovery and tranquil periods. Nevertheless, leading indicator models are still useful for early warning system construction, as historical data of best indicators did show extraordinary behaviour during non-precrisis periods.
Other handicap of this study lies on missing data replacement method for some variables. As current account, financial account, and GDP related items data are in quarterly data, linear interpolation is used to create data for inter-quarter months. In fact, data taken from linear interpolation is not the same as the actual data, hence it can lead to bias. Since there is no monthly data for these items, interpolated data is the only option available.

10.3 Further Suggestions

For further study, it is recommended to use best indicators from this study for further development of early warning system for Indonesia, as these indicators are proven to have excellent performance in predicting currency crises. However, one should not be oversatisfied with this result, as future currency crises may not be caused by factors that can be captured by these indicators. Continuous monitoring to the so-far best indicators is needed to measure their performance and reliability as components of early warning system.
REFERENCES


