VULNERABILITY ASSESSMENT ON EXTERNAL SECTOR: EWS FOR CAPITAL FLOW REVERSAL

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Foreword

Many factors should be taken into consideration in the assessment of external sector vulnerability. These key factors usually include external accounts, debt sustainability, capital flows and soundness of financial sector. This paper focuses on capital flows of the SEACEN member countries among the many key factors in the assessment of the external vulnerability. In the early 1990s, there was a surge in capital flows to emerging economies that was much larger than in the late 1970s and early 1980s. However, these flows reversed during the crisis period in late 1990's and recently capital flows are again rising to the levels before the crisis. While economic theory generally says that capital inflows are beneficial to economies, it has nonetheless been demonstrated that capital inflows could also lead to many problems and, sometimes serious crises, especially when the local economies lack strong fundamentals and financial institutions are poorly managed. In light of this, many developing countries are now attempting to monitor movements in capital flows in order to check, evaluate, and pre-empt the risks of these flows.

This paper is the output of the SEACEN research project, proposed to lay the foundations for the on-going work of the SEACEN Expert Group (SEG) on Capital Flows. The project aims to provide a review of the various early warning model methodologies and framework, and to assess the availability of historical data in member countries. As the SEG has been regularly sharing data on capital flows, the project is a step forward in using these data to regularly assess the vulnerability of the external sector of the member countries, especially in the light of volatile capital flows.

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Economist, are gratefully acknowledged. The views expressed in this paper, however, are those of the author and do not necessarily reflect those of the SEACEN and SEG member central banks, monetary authorities, or the SEACEN Centre.

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April 2005

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Abstract

As the SEG EWS is for capital flow reversal, a signaling approach was applied on all the candidate variables and contagion related variables in order to obtain some leading indicators which have some ability to issue a warning signal for capital flow crisis. More than 30 variables passed the typical noise-signal ratio of non-parametric EWS approach. All the variables selected are combined into a composite index (CI) and five sectoral indices. These indices were then tested for their abilities of predicting capital flow crisis.

The conditional probabilities of the CI in some ranges were examined and they were found to be capable for monitoring and assessing adverse movements of capital flows. A report providing a snapshot of the CI and signals of the individual indicators are to be shared among the member countries every quarter.

As the EWS presented in this paper is a preliminary one, the SEG needs to do more rigorous work on the robustness of the model using quality data prior to implementing and operating the EWS. The SEG should encourage more member countries to commit themselves to improve the system in which better data and information can be shared for the EWS work so that the project can move on to the next stage.

For further work, the data quality and coverage need to be improved for more rigorous and accurate capital flow crisis identification since this is one of the most important steps for the EWS. With quality data, the SEG would be able to consider and analyse in greater detail, the cyclical characteristics of capital flows. As usually expounded in boom and burst theory, capital tends to flow in for a short period of time before outflow and as sudden stops usually come in bunches and are clustered, more refinement is needed to clarify when a crisis starts and when it is over. The SEG should compare time series and chronological events and situations to pin point with greater accuracy when a crisis period starts and when it ends. The other issue is to explore more indicators for incorporation into the EWS model, especially contagion proxies and qualitative variables. In light of this, the SEG should continue to identify variables that are directly or indirectly related with contagion process or channel of capital flow crisis. As a longer–range plan, the SEG also hopes to incorporate higher frequency data, i.e., monthly data into the EWS model to better monitor capital flows.

1. Introduction

Many factors should be considered together for the proper examination or assessment of external sector vulnerability. These key factors usually include external accounts, debt sustainability, capital flows and soundness of the financial sector. In recent decades, the global economy has witnessed developments such as expanding trade flows, deepening of financial markets in many developing economies, integration of local financial markets to international markets and the growing importance of capital flows. In short, economies are becoming increasingly globalised through increased trade in goods, services and assets. The resulting higher domestic-international linkage may increase the vulnerability and susceptibility of many developing countries to external shocks.

This paper focuses on capital flows of the SEACEN member countries among the many key factors for the assessment of the external vulnerability. In the early 1990s, the surge in capital flows to emerging economies was much larger than in the late 1970s and early 1980s, but capital flows reversed during the crisis period of the late 1990's. Currently, capital flows are again rising to levels during the pre-crisis period. Economic theory generally suggests that capital flows are welfare enhancing as they permit higher growth through additional real capital accumulation. The other benefit of capital flows may include the promotion of technology transfer through FDI and the smoothing of consumption during poor harvest. However, it has also been widely noted that capital inflows could lead to many problems and sometimes, serious crises especially when the local economies lack strong fundamentals and financial institutions are poorly managed.[1] Many developing countries are now trying to monitor the movement of capital flows in order to check, evaluate, and pre-empt the risk of capital flows.

This paper is the output of the SEACEN research project proposed as part of the on-going work of the SEACEN Expert Group (SEG) on Capital Flows.[2]

1. FDI inflows increase foreign control, capital inflows may cause asset price bubbles, rising foreign debt together with external deficits can lead to an interest risk premium, and premature capital account liberalisation, especially with weak financial sector, frequently increases risks of financial crisis.

2. The SEACEN Expert Group (SEG) on Capital Flows was set up in May 2000 by the SEACEN board of Governors, and the sharing of data began in late 2001. The main objective of the SEG is to develop a regional framework to promote information sharing on capital flows. The SEG membership comprises 12 SEACEN members, and 3 observer central banks, namely Reserve Bank of Australia, Hong Kong Monetary Authority and the Bank of Japan. However, currently 12 members participate in data sharing, and the Central Bank of Myanmar and the Bank of Japan indicated that they are not ready to exchange data. The SEACEN Centre serves as secretariat to the SEG.

As the SEG has been regularly sharing data on capital flows, the project is a step forward in using these data to regularly assess the vulnerability of the external sector of the member countries, especially in the light of volatile capital flows. The project set out by reviewing the various methodologies and frameworks and by looking into the availability of historical data in member countries.

The project is conducted to set up an Early Warning System (EWS) in line with the purposes and objectives of the SEG, based on the studies and experiences from international financial institutions, individual central banks, and research on the topic. The objectives of this paper are: (i) to define the concept of crisis in capital flows for EWS, and to examine the contagion effects for an exploitative use of shared data among SEG member countries; and (ii) to assess the predictability of each leading indicator together with some contagion-related variables, and to compile a composite index for a complete EWS. The paper begins by reviewing general aspects of EWS established so far for various purposes, and looking into some empirical possibility of contagion among member countries. The next section covers the development of the EWS by applying the established methods and findings to adverse movements in capital flows discussed in the previous section. Further work and development of EWS are then discussed as a concluding remark.

2. Crisis and Contagion

2.1 General Aspects of EWS

Many factors come into play in the construction of the SEG EWS model. There have been many research and studies done over the years in developing and refining systems that have the capability of either predicting the likelihood of financial crises or assessing the current state of health of an economy. Therefore, there is the need to look briefly into the general aspects of popular EWS models established so far, in order to demonstrate the efforts of the SEG in incorporating many considerations into the SEG EWS model. One of the most important consideration is on what the EWS is directed at. The main purpose of an EWS may include forewarning on firm bankruptcy, banking crisis and currency crisis. While firm bankruptcy and banking crisis are the popular objects of EWS, EWS for currency crisis is now the most popular model. Secondly, sample coverage is also another important factor to consider. In some models, only data from one country are analysed, mostly used by the countries' authorities. In many academic studies, data from as many countries as possible are incorporated into the model. The scope of the sample and data is not only related

to the statistical significance, but it also affects the predictability of a future crisis through the availability of necessary data.[3] Lastly, the methodology would also be another factor. So far, econometric methods and non-parametric approaches are the most popular methodology for EWS, especially for practical purposes.[4]

The features of the SEG EWS are as follows: Firstly, the SEG EWS is aimed directly at predicting adverse movements in capital flows, in accordance with the main concerns of the SEG. This is the most important consideration as it is in line with SEG objectives, given the concerns that adverse movements in capital flows are increasing. Particularly, mobility of cross-border short-term capital flows is rapidly higher, volatility in capital flows is increasing and frequency of speed of the attacks also rises. In this respect, the crisis in capital movements is defined or identified by adverse movements in capital flows such as capital reversal or sudden stops based on the trend of capital flows and other economic variables such as GDP and current account deficit. The newly defined crisis in capital flows is a direct purpose of the EWS. The SEG, of course, delves into the relationship between adverse movements in capital flows and some economic events such as currency crisis and financial market disruption.

Secondly, the SEG model is basically a regional model and much emphasis is placed on the analysis of contagion effects. In other words, the SEG tries to share as widely as possible, data among SEG member countries. There is an attempt to include as many countries as possible and take advantage of detailed data presented by the SEG, in order to overcome the problem of general models.[5]

At the same time, it is noted that many efforts of individual countries may not be enough to monitor capital flows and deal with adverse movements of capital flows, mainly due to the disruptive nature of regional contagion, herding behaviour, and self-fulfilling expectations. These problems are growing more important as the international markets become increasingly integrated. To achieve

3. The most important advantage of the one country model, especially in the case of being set up by governments, is the possibility of using quite detailed and confidential data. A one country model, of course, have some disadvantages related with the limited experiences of crisis. In contrary, more general models usually have the merits that more experiences can be utilised, while they have faults in that some detailed data are not available and some specific structure or situation may be disregarded.

4. Of course, many other methodologies have recently been introduced in this field. Application of time-series techniques such as Markov switching model, and considerations of the economic loss or severity of the crisis together are among them.

5. Only five member countries are studied at this time due to many practical problems.

the goal of a satisfactory workable EWS, there is therefore a more detailed analysis on the regional contagion process and herding behaviour associated with capital flows among member countries.

The main methodology chosen is a non-parametric approach that would be more appropriate for incorporating various potential variables into the model. The non-parametric approach, normally known as the signaling approach, has been widely used as a general tool for EWS since Kaminky et al. (1997). The econometric method, usually based on logit-type model will also be conducted as a supplement methodology when needed in the process of managing the EWS in the future.

2.2 Crisis in Capital Flows

2.2.1 Identification of Crisis

For all empirical studies on EWS, dating the occurrence of crises is crucial to distinguish between tranquil periods and crisis episodes. The theoretical definition or empirical identification of crisis is one of the first and most important steps for EWS. There have been many discussions on how to measure and date some types of financial crises[6] such as currency, banking and debt crises.[7] As for capital flows, the main concerns should be given to the episodes of capital

6. Financial crisis should be defined in a broad sense covering banking crisis, currency crisis, and other crisis such as debt crisis. However, due to various reasons, it is quite common for the terms 'financial crisis' and 'banking crisis' to be treated as the same concept, and hence they are used interchangeably. However, the starting points of the crises could be different in many cases, and one crisis could actually lead to the other even when they appeared to take place at the same time. More importantly, the transmission and impact of the crisis on the economy may depend greatly on the origin of the crisis: whether it is from banking failure or disequilibrium in the foreign exchange market. In the end, banking and currency crises need to be conceptually differentiated.

7. Currency crises dating schemes normally rely on the calculation of an exchange market pressure index, and most methods use a more or less arbitrary threshold to identify crises. Other methods for finding currency crises dates are either qualitative approaches such as event studies or based on extreme values or Markov-switching models and do not employ arbitrary threshold.
The definition of banking crisis is more difficult to implement. Most of existing methods that are widely used to date banking crisis episodes are generally event-based. The systemic banking crisis episodes are characterised by events when the entire banking system has zero or negative net worth.
Debt crisis studies have one thing in common in that they start from a definition of a debt crisis or a debt service difficulty or default. Differences arise from the fact that some papers use combinations of debt crisis definitions, whereas others simply make use of single events or measurement of either debt rescheduling or arrears.

flow reversal or sudden stop, which may itself have triggered the ensuing economic disruption. This kind of a sharp contraction of capital inflows is usually associated with large depreciations and major financial disruptions, leading to significantly lower rates of return, investment and growth.

Applying some established measures of currency crisis to the concepts of capital flow reversal or sudden stop leads to the following definition of a *crisis period* in capital flows that should be fore warned: First, the crisis period contains at least one observation where the year-on-year fall in capital flows (proportional to GDP) lies at least 1.5 standard deviations below its sample mean, which addresses the unexpected and huge requirement of capital outflow. Second, the crisis period ends once the annual change in capital flows exceeds 1.0 standard deviation below its sample mean. This will generally introduce persistence, a common fact of crisis in general. For the sake of symmetry, the start of a crisis is determined by the first time the annual change in capital flows falls 1.0 standard deviation below the mean. In sum, a crisis in capital flows typically starts with a fall in capital flows exceeding 1.0 standard deviation, followed by at least one period of a fall of 1.5 standard deviations, and lasts until the change in capital flows is bigger than minus 1.0 standard deviation.[8]

Despite the conceptual definition of crisis in capital flows above, the actual identification of crisis is quite difficult, mainly due to unavailability of historical data. Given the unavailability of historical data on capital flows, the quarterly data on capital and financial accounts in the balance of payments (BOP) were used. Moreover, when considering recent crisis experiences, and data availability, the SEG EWS incorporates only 5 countries, namely, Indonesia, Korea, Malaysia, Philippines, and Thailand. The sample period is from the early 1980s, while it is from 1991 for Malaysia.

The results are presented in the Table 1. Thailand and Indonesia suffered more currency or banking crises than crises in capital flows – Thailand experienced one capital flow crisis, three currency crises and four banking crises, while Indonesia faced two capital flow crises and three currency and banking crises. Moreover, these countries did not suffer any capital flow crisis before 1997. For these two countries, capital flows have become important only recently. On the other hand, Korea and Malaysia suffered more crises in capital flows than currency or banking crises, which imply that all the adverse movements of capital

8. Crisis may, more often than not, start abruptly with a fall in capital flows of more than 1.5 standard deviations, and end with a sudden recovery of capital flows.

flows have not caused serious economic problems, at least in these two countries. As for the Philippines, capital flow crisis is relatively cross-related with currency and banking crisis.

Table 1
Crisis in Capital Flows

Country	Sample Period	Capital Crisis	Currency Crisis[1)]	Banking Crisis[1)]
Indonesia	1981:1~2003:4	1997:4~1998:1 1998:3	1992:4 1994:1 1997:3	1983:2 1986:3 1997:4
Korea	1980:1~2003:4	1981:3 1986:4~1987:1 1997:4~1998:1 2000:4~2001:1	1983:1 1986:1 1997:3	1980:1 1997:4
Malaysia	1991:1~2003:4	1994:3~1994:4 1997:3 1998:1 2000:2	1997:3	1993:4 1997:4
Philippines	1981:1~2003:4	1983:3~1983:4 1997:4 1998:3 2000:2 2002:3	1981:1 1983:2 1997:3	1984:2 1986:1 1990:4 1997:3 2000:4:
Thailand	1981:1~2003:4	1997:2~1998:2	1983:1 1996:2 1997:3	1981;3 1984:4 1997:3 1999:3

1) Only the starting time of crisis episodes (IMF, World Bank, ADB)

Table 1 also demonstrates the significance of major financial crisis such as the 1997 Asian crisis. It can be seen that during the 1997 crisis, all the five countries suffered all the crises - capital flow, currency and banking crisis, implying that the 1997 Asian crisis was a major financial crisis, which in turn explains the situation where common shocks were spilled over to all the involved countries at the same time for some reasons, or that some countries were badly affected by adverse conditions of the other countries, as suggested in some contagion

theories. It should also be noted that, except during major financial crises, the coincidence of capital flow, currency and banking crises are not quite a general phenomenon.[9] Crises in capital flows appear to be especially independent from currency and banking crises.

2.2.2 Relationships among Crises

The statistical relationships between currency/banking crisis and crisis in capital flows are investigated in order to demonstrate how deeply a crisis in capital flows is related with other financial disruptions across the five countries.[10]

Tables 2 and 3 present two-way frequency tables for crisis in capital flows and the currency and banking crisis, for the complete sample of five countries altogether. The Tables show that 60% and 56% of countries which succumb to a capital crisis also faced a currency and banking crisis, respectively. At the same time, 26% and 29% of those with currency and banking crisis also experience a crisis in capital flows. These relationships are not so different across the countries.

In order to test rigorously for the independence between crisis in capital flows and currency and banking crisis, some test statistics, the Pearson χ^2 and Likelihood G^2 statistics[11] are reported as follows. Note that the Pearson χ^2 and Likelihood G^2 test statistics have very small p-values, indicating that the observed rows and columns are significantly not-independent, and thus, the two different crises are statistically related as a whole.

9. Many studies explore some phenomenon of the coincidence of banking and currency crises, called twin crisis. Glick and Hutchison (2000) find that the twin crisis is more common in financially liberalised emerging markets, that the strong contemporaneous correlation between currency and banking crises in emerging market is robust, and that the occurrence of banking crises provides a good leading indicator of currency crises in emerging markets.

10. As for currency and banking crises, some sources are based on annual basis, while others represent only the starting time of the crises. The starting time of those crises have been taken and the assumption is made that those crises last 4 quarters for this analysis.

11. The test statistics are based on the distance between the actual cell count and the count expected under the independence. The actual statistics are computed in the following way:
Pearson $\chi^2 = \sum_{i,j} (\hat{n}_{i,j} - n_{i,j})^2 / \hat{n}_{i,j}$, Likelihood Ratio $G^2 = 2\sum_{i,j} n_{i,j} \log(n_{i,j} / \hat{n}_{i,j})$
where $n_{i,j}$ and $\hat{n}_{i,j} = \left(\sum_i n_{i,j} / N\right)\left(\sum_j n_{i,j} / N\right) N$ are the actual and the (overall) expected count in each cell.

Table 2
Crisis in Capital Flows and Currency Crisis

	No Capital Crisis	Capital Crisis	Total
No Currency Crisis	275	10	285
Currency Crisis	42	15 (26.3%) (60.0%)	57
Total	317	25	342

Pearson $\chi^2(1)=36.5$, p-value=0.00
Likelihood ratio $G2(1)=26.6$, p-value=0.00

Table 3
Crisis in Capital Flows and Banking Crisis

	No Capital Crisis	Capital Crisis	Total
No Banking Crisis	283	11	294
Banking Crisis	34	14 (29.2%) (56.0%)	48
Total	317	25	342

Pearson $\chi^2(1)=39.4$, p-value=0.00
Likelihood ratio $G2(1)=27.1$, p-value=0.00

2.3 Crisis Contagion

2.3.1 General Aspects of Contagion

After identifying crisis periods in capital flows, the concern that the adverse movements in capital flows would spread to other member countries through the process or channel of crisis contagion is looked into. Crisis contagion is now one of the most important concerns of financial disruption. The importance of the contagion effect is rapidly growing as financial markets become more internationalised. More attention has been paid on contagion especially after the 1997 Asian crisis, with 3rd and later generation theories of currency crisis.[12] As for the empirical analysis, the established and well-known concepts and facts on general crisis contagion are applied to the crisis in capital flows.

Despite its growing importance, crisis contagion is not defined with a normal consensus, and contagion effects are not at all easily captured, empirically measured and tested. Some define a crisis contagion in a broad sense as the phenomenon of a crisis in one nation precipitating a similar crisis in another nation, especially within the same region. This definition is based on the argument that there is no *pure* contagion without some fundamental domestic economic problems and that what appears to be contagion is merely symmetric structural weakness. On the other hand, others narrowly define a contagion as specific transmission channels that we observe only during periods of crisis and that cannot be explained by the standard propagation channels emphasised in the broad definition. They believe that the excess variation and co-movement during the time of economic turbulence, not captured by the standard channels, constitutes contagion. The point is whether crisis happenings in many countries at almost same time can be properly explained only by fundamental and structural weaknesses and some linkages.

12. The theory of currency crises distinguishes between several crisis types according to their causes. Currency crisis literature describes three generations of models explaining the causes of currency crises. The first generation models, called speculative attack models, pay attention to the overly expansive domestic policies preceding the crises of Mexico and Argentina before early 1980s, and show how a rigid exchange rate policy combined with excessively expansionary pre-crisis fundamentals push the economy into crisis, with the private sector trying to profit from dismantling the inconsistent policies. The second generation theories, in response to the crises of Europe and Mexico in the 1990s unrelated to the economic fundamentals, show that even when policies are consistent with the fixed exchange rate, attack-conditioned policy changes can pull the economy into an attack. The second generation theories, called exit clause models, stress the self-fulfilling characteristics of a crisis and the occurrence of multiple equilibria. The third generation theories emphasise the consequence of moral hazard to the banking system and the contagion effect as the key determinants of crisis, especially the 1997 Asian crisis.

Defining a crisis contagion is not as big a problem in comparison to empirical work for practical purposes or policy implications. Most of these empirical difficulties are associated with the lack of proper measures or proxies of contagion. Some measures and proxies such as correlations of rates of return, and exchange rate changes of trading partners are widely used but they are not clearly well-defined, and therefore, are not enough from the policy point of view.

Before evaluating the contagious nature, the processes of contagion are first examined. For illustration, three types and three channels of contagion are adopted. The first type of contagion is monsoonal contagion, which occurs when common random external shocks hit a number of countries in a similar way at almost same time. This type is not so common among developing countries, and in most of cases, random external shocks normally originate from some influential developed countries. The second and most general type among developing countries is the spillover/linkage contagion, in which crisis in one country is spilled over into other countries through normal inter-dependences, such as those produced by trade and financial linkages. Another important type is pure contagion.[13] Unlike other types, this type of contagion is due to factors that are not related to a nations' fundamentals, but by non-fundamental uncertainties. In other words, with this type of contagion effect, we cannot easily identify the problems that are causing some countries to suffer a similar crisis at the same time, other than some vague facts like that they are all developing countries or that they are all in the same geographical region.

The channel of contagion is mainly based on what fundamental deteriorations are involved in the processes of contagion. The first one is the macroeconomic channel in which countries may affect other countries in a region that share similar weak fundamentals. Such weak fundamentals increase the vulnerability of a nation to a speculative attack and its rapid replication in other nations in the same region. The most important channel that has long been discussed is the trade channel. Crisis in one country has direct negative effects on its major trading partner, which is usually through what is called a direct trade channel. The other class of trade channel is the indirect trade channel, which can be explained by the situation in which the drastic devaluation of one nation in crisis could undermine the export competitiveness of the others and which could lead to other countries' suffering of an external shock. The other channel is the financial channel, which is now becoming more important with the integration of international financial market, mainly through cross-country financial links. Illiquidity

13. As mentioned before, the narrow definition of contagion contains only pure contagion.

in one national market may compel financial intermediaries to liquidate assets in other markets in the same region. Regional concentration of cross-border asset holdings results in the spread of crisis regionally.

To incorporate some relevant contagion effects into the EWS, the broad definition of contagion is adopted and three processes of crisis contagion are examined, namely the trade channel, financial channel, and pure contagion. The possibilities of the existence of the trade and financial channel, and the evidence of pure contagion among the SEG countries are evaluated, since the monsoonal and macroeconomic channels can be measured and explained, at least indirectly by other macroeconomic variables and leading indicators of EWS.

2.3.2 Trade Channel

Based on the trade channel, the inverse relation between trade and distance supports the contention that countries in the same region are susceptible to crisis contagion through the trade channel. This explanation is usually captured by the gravity model. So far, empirical evidences also support this kind of assertion in general. As for a trade channel possibility among Asian countries, empirical work suggests that the trade channel plays an important role in transmitting crisis in the region.[14]

The possibility of a trade channel among SEG countries is confirmed by examining the trade structures of those countries. A direct channel is first considered. According to recent data, bilateral trade shares among the five countries under study are less than 10% of total exports in all cases (Table 4). These shares are relatively small compared to trade shares with other countries such as US, Japan, and China (Table 5). It can, therefore, be safely concluded that direct trade channel may not have a significant role in propagating the crisis among five countries.

14. As for empirical work on trade channel, see Eichengreen and Rose (1998), Kochar, Loungani and Stone (1998), and Kim, Kose and Plummer (2001).

Table 4
Bilateral Trade among the Countries (2003)

	Indonesia	Korea	Malaysia	Philippines	Thailand
Indonesia					
Korea	3.04				
Malaysia	2.76	2.24			
Philippines	1.29	1.83	2.87		
Thailand	2.67	1.46	4.62	2.52	

Share (%) against total exports, computed from East Asian Economic Perspectives by ICSEAD

As seen in Table 5, trade dependencies through third market linkages such as US, Japan and, China are relatively strong, indicating that indirect channels are likely to occur through sudden shifts in relative competitiveness in those third markets. While the possibility of an indirect trade channel has been suggested and confirmed in many related work, it should be noted that the influence of this channel may not be very large among the countries. Analysing the trade structures, the relative importance of each major partner is different among the countries. From Table 5, while it can be seen that the US is one of the most important importers of all countries, the relative importance of other major importers differ across countries. For example, while China is the most important importer for Korea, it is not so for the other 4 countries. Conversely, Japan is most important for Indonesia while Hong Kong and Singapore for Malaysia.

Moreover, the components of exports are significantly different across the countries. The second panel of the Table shows that agricultural products comprise 14% and 11% of the exports of Thailand and Indonesia respectively, while in Korea they account for only 1%. Crude materials and mineral fuels are 35% in Indonesia and 14% in Malaysia, but in the other countries, they account for only 2~7%. Machinery exports consist of more than 50% of the total exports for Korea and Malaysia, while in Indonesia they constitute only 16%.

In sum, the indirect trade channel is likely to play some role in precipitating the crisis among the five countries but it should not be overemphasised taking into consideration the current structures of the countries' exports.

Table 5
Exports by Major Partners and Commodity Groups (2003, %)

	Indonesia	Korea	Malaysia	Philippines	Thailand
Total exports (US$ million)	61,556	192,182	98,288	35,446	79,778
Japan	22.0	9.0	11.0	15.4	14.2
United States	12.5	17.6	17.7	20.9	17.1
Industrial Europe	13.4	13.7	13.0	16.9	15.8
China	5.9	18.3	6.2	5.6	7.0
Hong Kong and Singapore	0.6	9.6	22.7	15.4	7.4
Others	35.5	31.8	29.3	25.9	38.5
Agricultural products	10.9	1.4	9.4	6.3	14.2
Crude materials excluding fuels	8.7	1.0	2.7	1.1	4.9
Mineral fuels	26.0	1.0	10.9	1.5	2.5
Chemical manufactures	5.4	8.8	5.4	1.1	6.0
Machinery manufactures	15.8	62.6	54.0	41.0	44.1
Other manufactures	32.7	21.8	16.3	10.5	25.3
Not classified	0.5	3.4	1.4	38.6	2.9

Computed from East Asian Economic Perspectives by ICSEAD

2.3.3 Financial Channel

While the financial channel is directly related to the behavior of international investors, it would be a challenge to explain the motives and reasons behind this type of herding behaviour and also the magnitude of its effects on the economy. It is much harder to examine the empirical possibility of contagion through the financial channel than the trade channel, mainly because of data unavailability. For example, there are few consistent sources of information on direct financial linkages among the SEACEN member countries. Transmission through financial markets can also be divided into direct and indirect channels as in the case of the trade channel. Again, it can be assumed that the direct financial linkages are probably less problematic given that a substantial proportion of the external funding to member countries comes from main financial centres in developed markets. Although much empirical work on the financial channel

focus on the indirect channel, there has been no clear conclusion on the relative importance of the financial channel.[15]

To derive a more definite conclusion on the relative importance of the financial channel in contagion, we need more practical data and more concrete empirical studies such as the role of hedge funds, mutual funds, and other foreign institutional investors. Here, some ways to measure market competition in banking centres of developed countries is considered in order to supplement the empirical work on the possibility of a financial channel among the SEG member countries. Two measures are adopted – those by Van Rijckegehem and Weder (2001), of credit inter-linkages which distinguish between absolute or relative competition for funds available.[16] The formula for the absolute competition index ($A_{i,j}$) and relative competition index ($R_{i,j}$) in banking financing are respectively as follows:

$$A_{i,j} = \sum_{c} \left(\frac{b_{ic} + b_{jc}}{b_i + b_j} \right) \left[1 - \left(\frac{|b_{ic} - b_{jc}|}{b_{ic} + b_{jc}} \right) \right]$$

$$R_{i,j} = \sum_{c} \left(\frac{b_{ic} + b_{jc}}{b_i + b_j} \right) \left[1 - \left(\frac{|b_{ic}/b_i - b_{jc}/b_j|}{b_{ic}/b_i + b_{jc}/b_j} \right) \right]$$

where b_{jc} denotes the stock of debt of county j in banking centre c, and b_j is the total debt of country j, which is actually the summation of b_{jc} over the centre c_s'. Actually, the first terms of the two formulae are the share, and thus importance of the banking centre c, to both countries i and j as a whole, which plays a role as a weight in the formula implying the indices are the weighted average. The second terms are differences of countries i and j in the banking centre, either in absolute amount or in relative importance. The indices should therefore be between 0 and 1, and they approach closer to 1 as the two countries, i and j compete higher with each other in all the involved banking centres. As a whole, the absolute index in which a larger borrower represents greater competition for funding, the propagation mechanism may be margin calls if fund supply is limited. By contrast, under the relative index, which indicates similarity in borrowing pattern (as a share of total borrowing), the propagation mechanism may be through the informational spillovers.

15. See Kaminsky and Reinhart (1998), Van Rijckeghem and Weder (1999), Kim and Wei (1999), and Kim, Kose and Plummer (2001), for empirical work on financial channel.

16. Van Rijckegehem and Weder (2001) originally followed the approach of Glick and Rose (1999) to trade linkages, proposing two indices of multi-creditor bank links between emerging market economies.

The absolute and relative competition indices were computed for the 5 countries, using BIS data on the origin and destination of bank financing (Consolidated Foreign Claims) in 2003. 14 major common creditors were considered.[17]

Table 6
Banking Financing Competition Index (2003)

	Indonesia	Korea	Malaysia	Philippines	Thailand
Indonesia	1.00 (1.00)				
Korea	0.54 (0.72)				
Malaysia	0.61 (0.59)	0.59 (0.70)			
Philippines	0.70 (0.77)	0.41 (0.86)	0.59 (0.72)		
Thailand	0.73 (0.74)	0.55 (0.71)	0.64 (0.68)	0.68 (0.69)	1.00 (1.00)

Absolute competition index and relative competition index in the parenthesis.

As discussed earlier, the potential for finance spillovers via the major creditors are captured by the banking financing competition indices. Table 6 shows that the indices between the Indonesia and Philippines, Indonesia and Thailand, Philippines and Thailand are large in terms of both the absolute and relative competition indices. This shows that the competitiveness for financing from the main banking centres between these pairs of countries is very high and therefore, the risk of the propagation through the margin calls is high among these countries, especially when the fund is limited. Based on a relative index computed, the financing structure of Philippines is similar to those of Indonesia and Korea, implying the higher potential for financial contagion among these countries through informational spillovers. The relative indices are in particular, bigger than absolute indices, and the possibility of informational spillover is higher than that of spillover through the margin calls among the countries.

As a whole, all competition indices are sufficiently large to assume the high possibility for some crisis propagation through financial channel among the member countries.

17. They are Austria, Australia, Belgium, Canada, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, UK and US.

2.3.4 Pure Contagion

Pure contagion or what is sometimes called sunspot contagion is very difficult to evaluate since it is related to changes in behaviour of international investors not caused by systematic or mechanical changes in their portfolio composition, but influenced by shifts in their perception towards market risk.[18] Related terms include herd behaviour, informational cascades, demonstration effect, wake up call, etc.[19] Pure contagion has been tested in relatively few papers, but it was found to play a big role in precipitating some crises. Most researchers estimated pure contagion by using residuals of cross-country correlations that cannot be explained by fundamentals or other spillover channels. They focused especially on the rates of return.[20]

For pure contagion, empirical work done here is focused on the evidences of past experiences rather than the possibility or potential of contagion due to the irregular nature of pure contagion. The concentration is on an extension of the empirical analysis of capital flows, instead of rates of return on some capital market. To provide evidence on the changes in the movements of capital flow during the crisis, the Granger causality test was applied. The following equations were estimated to find out whether or not the relationships between the movements of capital flow in two countries change drastically and unexpectedly during a crisis.

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18. This is why pure contagion is called sunspot contagion. Sunspot used to refer to "non-fundamental uncertainty" which matters in the economic phenomena. Since Cass and Shell (1982), many theoretical works have showed that equilibrium affected by sunspot, called sunspot equilibrium, can exist in the rational expectation framework in many relevant fields. Compared to the theoretical work, there has been relatively little empirical work on sunspot equilibrium, mainly because it is difficult to identify or measure the sunspot variables in the involved problems. As for sunspot contagion, there has been little empirical work done due to the same reasons.

19. "Herd behaviour" explains the situation in which investors pay close attention to other investors' behaviour in the market, partly because they worry about their relative performance in the market compared to others'. In that situation, as one investor moves, especially a market leader, others are very likely to follow. "Informational cascade" works when investors tend to consider all developing countries as the same, instead of evaluating countries individually, considering their fundamentals separately. Even in the presence of scrupulous investors who closely follow fundamentals, contagion can still occur. When countries with similar fundamental imbalances face attacks on their currencies, investors reevaluate the economic conditions of other countries and withdraw their investments from these countries. This process pushes these countries into crisis. This mechanism is called the "demonstration effect" or "wake-up call."

20. See Kim and Wei (1998), Kodres, and Pritsker (1999), and Sander and Keimeier (2002).

$$CF_{i,t} = \alpha_i + \sum_{k=1}^{m} \beta_k^{ij} CF_{j,t-k} + \sum_{k=1}^{n} \gamma_k^{ij} CF_{i,t-k} + \varepsilon_t^{ij}$$

$$CF_{j,t} = \alpha_j + \sum_{k=1}^{m} \beta_k^{ji} CF_{i,t-k} + \sum_{k=1}^{n} \gamma_k^{ji} CF_{j,t-k} + \varepsilon_t^{ji}$$

$CF_{i,t}$ is the capital flow of country i in time t, and $CF_{j,t}$ is the capital flow of country i. Here, the standard F-test of estimate βs' being zero determines the existence of causality between the movements of capital flows in two countries. As usual, the capital flow of country j is said to Granger-cause the capital flow of country i when the null hypothesis in the first equation cannot be statistically rejected. The same can be said for the capital flow of country i by checking the null hypothesis in the second equation.

It would be ideal to estimate the relationships of cross-country causality separately, over the crisis period and tranquility period and compare and conclude whether or not the relationships change drastically during the crisis period. However, the relationship cannot be estimated properly over the crisis period because of insufficient number of episodes of crisis compared to the number of coefficients to be estimated. Therefore, the estimations is made for the relationships just over the whole period and sub-period excluding the crisis period, in order to check indirectly the influence of the crisis on the causality relationships of capital flows in two countries.

Figures 1 and 2 give an overview of the results. In the Figures, solid arrows indicate causality at a significance level of at least 10%. Figure 1 shows that in the tranquil period (the sub-sample excluding crisis period) there is a virtual absence of a strong causality pattern with some exceptions. Only 5 cases of cross-country causation were found among five countries. In particular, the capital flows in Korea is totally independent from those in the other countries, and Malaysia is also relatively remote from the other countries. On the other hand, the capital flows in Thailand were relatively interdependent on those in the other countries. Figure 2 depicts the case of the whole period including the crisis. When the crisis periods are included, there is a stronger pattern of cross-causality among the capital flows in the 5 countries, with 9 causations confirmed.[21]

21. Note that the whole period includes more tranquil periods than crisis periods. Considering the already established fact that there is no strong causality pattern in the tranquil period, the cross-country causality pattern only in the crisis period could be much stronger than that of the whole period.

The movements of capital flows in Korea and Malaysia are now related with those in the other countries, and Thailand becomes more inter-locked with the other countries.

Despite the limited data and analysis, the results can be interpreted as the crisis increasing the cross-country causality among the movements of capital flows in the countries. The finding is supportive of the claim that the crisis itself, to a considerable degree, may influence the movements of other countries' capital flows, and, in turn, precipitate the crisis, through, so called, pure contagion. In sum, the past evidence of the adverse movements transmitted through pure contagion is sufficient enough for the countries to be watchful about the movements of capital flow in the other countries.

Figure 1
Causality of Capital Flows in Tranquil Period

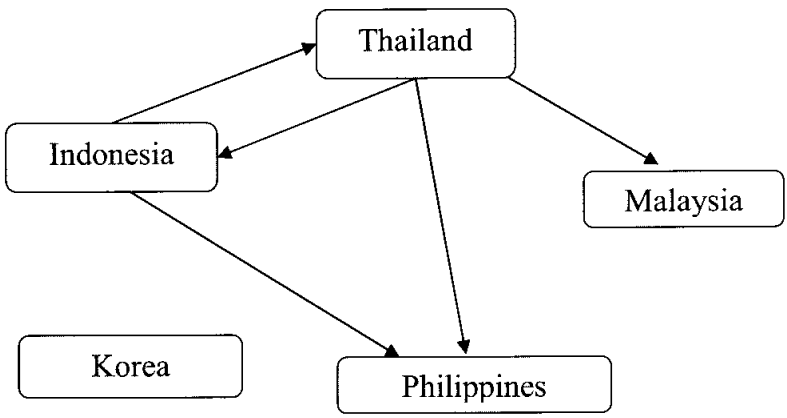
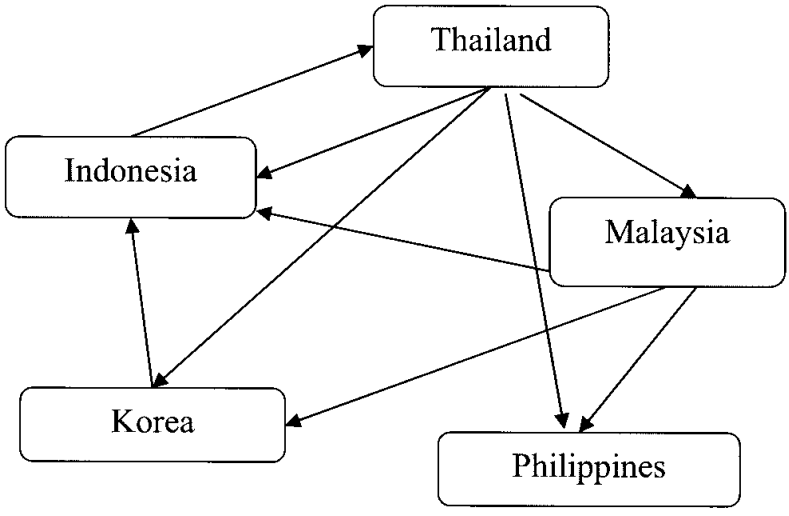


Figure 2
Causality of Capital Flows in the Whole Period



2.3.5 Proxies of Contagion

It was seen that contagion, through the indirect trade channel, indirect financial channel, and pure contagion, are more likely to have a significant role in propagating a crisis among the countries. While there is a confirmed potential risk of contagion, it is a difficult problem to decide which economic variable or measurement should be monitored and examined. There are no unique variables that can properly proxy or represent each channel or type of contagion.

This paper tries to incorporate some proxies of contagion into the SEG EWS for capital flow crisis, since the EWS would be less useful if it disregarded contagion and its related variables. Based on the process of contagion and economic theory, it is presumed that some variables are related with crisis contagion. First, the trade channel can be proxied by the nominal effective exchange rate (NEER), terms of trade, and trade balance while short-term capital outflow and credit ratings are very much related to the indirect financial channel. Pure contagion is more vague as seen before, but it can be approximated by the crisis itself, and by some political and social events.

Some variables and proxies were selected, and tested in the same way that the EWS signaling approach was applied to the individual leading indicators of external positions and macroeconomic fundamentals.

3. Early Warning Model

3.1 Leading Indicators

3.1.1 The Signals Approach

The first step in constructing a EWS is to select some leading indicators, based on the ability of each indicator to emit a signal prior to the occurrence of a crisis. More needs to be discussed about the signals approach used to evaluate the predictability of each variable to provide an advance warning signal on an impending crisis.[22]

The approach is univariate in that each variable is analysed separately. It involves monitoring each variable and identifying when a variable deviates from its 'normal' level beyond a certain 'threshold' value. For these extreme values, a variable is said to give a warning signal of a possible crisis.[23] It should be noted that thresholds are defined relative to the 'percentile' of the distribution of the indicator. For example, if the optimal threshold for the growth rate is 5th percentile, then one determines the value of growth rate at the 5th percentile of its distribution for each country. The actual value varies across countries, but the same percentile is applied for all the countries.

22. In general, the design of an early warning system requires the following three main considerations: i) the definition of a crisis, that is, the statistical dating of the crises; ii) the scope of the model such as country coverage, choice of explanatory variables, and time dimensions; iii) the statistical methodology, i.e. signal approach or probit analysis. In previous section, definitions of capital flow crises and the scope of the model are already chosen and explained.

23. Let X be defined as an indicator variable. Then X is said to "signal" a crisis in period t if in that period the indicator crosses the critical threshold, $\bar{X}$. The signaling state is characterised by

$$S_t = 1 \text{ if } |X_t| > |\bar{X}|$$

If X does not exceed this threshold, X , then there is no signal.

$$S_t = 0 \text{ if } |X_t| \leq |\bar{X}|$$

Note that for some variables, a decline in the indicator below some value indicates an increase in the probability of a crisis, while for other variables the rise above the threshold value indicates an increase in the probability of a crisis. Thus, the conditions in the above equations are expressed in terms of absolute values.

A 'good' signal is one that leads a crisis within a signaling horizon or a crisis window (here, of 4 quarters). When a variable gives a signal and a crisis does not follow within the crisis window, it is considered a 'bad' signal or simply a noise. Consequently, the optimal threshold is calculated for each variable so that it minimises the noise-to-signal ratio, which is the ratio of bad signals to good signals calculated for a range of potential threshold values, and the value minimising the noise-to-signal ratio becomes the threshold of the indicator.[24] Minimisation to get 'optimal' threshold is through the method of grid search process.[25]

After obtaining the 'optimal' threshold, the performance of each indicator is evaluated based on some criteria. The most common criterion is the noise-signal ratio itself. The other measure is conditional probability, i.e., the probability of crisis when a signal is issued.[26] Normally, the selected indicator is one which the minimised noise-signal ratio is less than 1.

24. In the signals approach, the outcomes for an indicator can be considered in terms of a two by two matrix as shown below.

	Crisis within 4 quarters	No crisis within 4 quarters
Signal	A	B
No signal	C	D

For each variable, there are four possible categories. A variable can issue a signal (row 1), indicating it is above (or below) the threshold, or it fails to give a signal (row 2). When a variable gives a signal and a crisis follows within 4 quarters, the signal is considered a good signal (cell A). A variable that gives a signal and a crisis does not follow is considered noise or a "bad" signal (cell B). A variable that does not give a signal and a crisis follows is a "missed" signal (cell C) and an indicator variable that does not give a signal and no crisis follows is a "good silent" signal (cell D). For any variable and given threshold level, the quarterly signals issued by that variable can be placed into cells A, B, C, or D. The key to the signal extraction approach is to choose the threshold level so as to strike a balance between the risks of having many bad signals and the risk of missing many crises. The thresholds are calculated to minimise the noise-to-signal ratio. In terms of the matrix, this implies minimising the ratio: [B/(B+D)]/[A/(A+C)].

25. Here, the grid search process was done from the 80 to 95 percentile for some indicators or, 5 to 20 percentile for the other indicators, according to the nature of each variable.

26. In terms of the above matrix, conditional probability is represented by A/(A+B).

3.1.2 Selected Individual Indicators

More than 35 variables were chosen as potential indicators, based originally on the many already established studies on currency crisis and capital flows. Most variables were of external positions and macroeconomic fundamentals and mostly derived from well known sources such as the IFS and central banks' websites. Little SEG data were used because of the limited historical range even though the SEG database is quite extensive.

Based on the noise-signal ratio, 26 variables were selected.[27] When categorising the selected variables roughly into several sub-sectors for convenience, 8 variables of external sector, 8 financial sector variables, 5 variables of real sector, and 5 variables related to global economic environments passed the noise-signal ratio and had relatively good predicting power for a crisis. As for data sources, 7 variables from the SEG database were relatively good indicators for a crisis in capital flows.

- External sector indicators (8): short-term external debt/foreign reserves, foreign currency liabilities to residents, real effective exchange rate, terms of trade, foreign reserves, nominal effective exchange rate, current account/GDP, volume of FX transaction.
- Financial sector indicators (8): swap points, net foreign assets, domestic credit, external liabilities/assets, stock market capitalisation, interest rates, money stock (M2), interest rate spread.
- Global environmental variables (5): US Dow Jones index, OECD leading indicators, S&P sovereign ratings, US interest rates, OECD production index.
- Real sector indicators (5): inflation, production index, unemployment rate, share price, government balance/GDP.

The major leading indicators are represented in Table 7.[28] First, it can be seen that short-term external debt against foreign reserves, real effective exchange rate deviation from its trend, terms of trade and net foreign asset, are quite good

27. All the indicators are tested in the form of year-on-year change, except variables in the ratio form, interest rates, and real effective exchange rate (REER). All the variables in the ratio form and interest rate are used themselves without any transformation, and REER is the deviation from its trend.

28. Predictability of some indicators should be interpreted with caution despite its very low value of noise-signal ratio. For example, swap points do not have statistically enough observations yet, and short-term external debt is only for two countries, Korea and Malaysia.

predictors of capital flow crisis. They are normally known as good indicators for currency crisis, and sometimes even for the banking crisis. As such, we can be confident that these variables are significantly related to external shocks and financial crisis. One more thing that can be noted is that some variables related to the market situation of developed countries such as the US DJ index and OECD leading indicator are also very good indicators for crisis in capital flows, reflecting that most flows to SEG countries are from the developed countries. Finally, indicators from the SEG database such as swap points, foreign currency liability to residents and stock market capitalisation are also very good indicators.

Table 7
Major Leading Indicators

Leading Indicator	Threshold (percentile)	Noise signal ratio	Conditional probability
Swap Points	5.4	0.00	1.00
Short-term external debt	92.8	0.07	0.86
FC liabilities to residents	6.4	0.10	0.71
Real effective exchange rate	94.9	0.11	0.73
Terms of Trade	7.5	0.17	0.68
Net foreign assets	5.4	0.20	0.50
Domestic credit	94.9	0.24	0.46
US DJ index	91.7	0.25	0.44
External Liabilities/Assets	94.9	0.28	0.46
Stock market capitalization	5.4	0.31	0.50
Foreign reserves	6.4	0.33	0.38
Interest rates	93.8	0.35	0.36
OECD Leading indicators	81.3	0.38	0.34

In addition to the above mentioned variables, some proxies related to the contagion process also meet the criterion of the noise-signal ratio and conditional probability. For these contagion related variables, each variable of one county is tested to find out whether it has the ability to provide an advance warning signal on an imminent capital flow crises of the other four countries.

- Contagion related variables (3): nominal effective exchange rates, capital flows, crisis in capital flows.

Table 8 summarises the performances of the contagion proxies based on the same signaling approach. The nominal effective exchange rate (NEER) related to the indirect trade channel of contagion turns out to be a good indicator. Especially, NEERs of Korea and Malaysia performed very well in predicting the crisis of the other countries. Capital flow,[29] representing the financial channel,

Table 8
Contagion Related Variables

Variables	Origin country	Threshold (percentile)	Noise-signal ratio	Conditional probability
NEER	Korea	93.8	0.10	0.69
	Malaysia	94.9	0.14	0.55
	Philippines	89.7	0.50	0.24
Capital outflow	Indonesia	87.6	0.34	0.40
	Korea	94.9	0.22	0.45
	Malaysia	93.8	0.19	0.58
	Philippines	90.7	0.27	0.37
	Thailand	94.9	0.02	0.90
Crisis happening	Indonesia	-	0.22	0.50
	Korea	-	0.51	0.31
	Malaysia	-	0.45	0.40
	Philippines	-	0.60	0.25
	Thailand	-	0.10	0.73

29. Short-term (private) capital outflow may be much better proxy than capital outflow itself.

performed very well, and in this case, the influence of capital flow in Thailand was relatively high. The crisis itself, taken to be a proxy for pure contagion, can also be a very good indicator. The crises of Thailand and Indonesia were found to have very low noise-signal ratios and high conditional probabilities, partly due to the experience of 1997 Asian crisis.

3.2 Composite Index

3.2.1 Compiling Composite Index

After selecting the leading indicators, the threshold for each indicator could now serve as the reference point in monitoring the indicators' movements with respect to a possible crisis in capital flows. For instance, if the short-term external debt of one country (compared to foreign reserves) increases above its historical 93% percentile level, then it is signaling that a crisis will occur within the next 4 quarters. The thresholds of the 26 indicators could be used in a similar way to monitor and pre-empt a crisis in capital flows through a signal emitted by an indicator at any given time.

However, looking into only the individual indicators is not enough in most practical cases[30] and a composite index is normally compiled to obtain more comprehensive information from the movements of all the selected indicators. The EWS is completed here by combining all selected variables and contagion proxies into a composite index (CI) for each country. The SEG composite index of crises in capital flow is a weighted sum of all the selected variables and contagion proxies as follows:

$$CI_t = \sum_{i=1}^{p} w_i \frac{\left| v_{i,t} - m_i \right|}{\sigma_i}$$

30. Each indicator has a different predicting power for the crisis, and may sometimes show slightly conflicting movements from one another.

The weight (w) used above is the conditional probability.[31] The higher the conditional probability of a leading indicator, the bigger is its weight. Each variable should also be standardised by its own standard deviation, since each variable has a different size of variation inherently and this inherent variation should be adjusted in order not to influence the composite index. For the CI to be in the similar form to the normal index, each variable is expressed in the extent of deviation from its minimum or maximum, guaranteeing that the CI is positive and higher as the probability of crisis grows.[32]

Based on the grouping of the selected variables mentioned above, five sectoral indices are also computed in the same way for the composite index: external leading index (SE), financial leading index (SF), real leading index (SR), global leading index (SG), and contagion leading index (SC).

The movements of the CI and sectoral indices are presented in Figures A.1~A.5 in the appendix for each country. As a whole, all the indices move very closely to one another in all the countries. Most of the indices grew significantly in all the countries before the 1997 Asian crisis, reflecting that the 1997 crisis was a major financial disruption in the countries. Despite the overwhelming 1997 crisis, most of the indices seemed to miss few of the other crises in capital flows. The CI seems better in issuing a proper warning signal than any other sectoral indices. Among the sectoral indices, the contagion leading index (SC) and the external leading index (SE) seem to move closely to the CI in all the countries. Particularly, the fact that SE moves closely to the CI confirms again that the crisis in capital flows was highly related to, or caused by some external shocks. The effectiveness of the SC, even though it was partly due to the influence of the 1997 crisis, deserves to be looked into for the purpose of EWS.

The contributions of each sectoral index to the CI differ across countries even though SE, SC, and SF are more important sectors and the SG and SR are less important in general. For example, in Indonesia, the SF is the biggest sector index over the whole sample period, while the SE is the biggest in Korea, and the SC is the biggest in the other countries. The SG accounts less relatively for the CI, and SR contributes the least to the CI of all the countries.

31. The inverse of the noise signal ratio is also used as a weight. Here the ratio is not used because some indicators have very small (even zero) values of the ratios, and therefore huge weights compared to the other indicators.

32. However, the CI needs not be one scaled from zero to one hundred like a normal index.

3.2.2 Evaluating Composite Index

For a more rigorous evaluation of the composite index, a similar test that was done for the individual leading indicators, noise-signal ratio and the conditional probability for the optimal threshold, were computed for the CI and 5 sectoral indices.[33]

The tests conducted on the CI of 5 countries are represented in Table 9. As can be observed, the CI gives promising results as a whole for the two criteria. First, the CI has a low noise-signal ratio of 0 to 0.08 indicating that it will deliver at most one false signal for every 12 correct signals of an impending crisis. Note that the noise signal ratios in Philippines and Indonesia are very low at 0 and 0.02, respectively. With a signal of the CI, the probability (conditional) of a crisis within one year is at least higher than 60 percent. Based on the conditional probability, the CI performed very well for Malaysia and Indonesia in addition to the Philippines.

The optimal thresholds in percentile are not so different across counties, while the levels of optimal threshold differ slightly across the countries. The threshold of Korea is relatively low, and that of Indonesia is high, compared to those of the other countries.

Table 9
Composite Index of Crisis in Capital Flows

Country	Threshold (percentile)	Threshold (level)	Noise signal ratio	Conditional probability
Indonesia	94.6	39.7	0.02	0.83
Korea	91.3	29.9	0.08	0.75
Malaysia	94.6	32.7	0.05	0.83
Philippines	94.6	32.6	0.00	1.00
Thailand	95.7	27.2	0.07	0.60

33. Out-of-sample test is one of the most widely used in testing the predictability. However, it is not properly conducted because the data is too limited, and the sample of crisis period is rare compared to the tranquil period. For example, when the recent crisis of 1997 is reserved for out-of-sample prediction, the proper signaling approach cannot be conducted only with the remaining few minor crises.

The same approach is conducted for the sectoral indices across the countries, the results of which are reported in Table A.1 in the appendix. Among the sectoral indices, the external sector and contagion indices are the best rivals for the composite index with the predictability of the SE being almost as good as that of the CI. The noise-signal ratio of the SE is between 0.0 and 0.11, and the conditional probability is also high, ranging from 0.5 to 1.0. The noise-signal ratio of the SC is also between 0.02 and 0.23. The conditional probability of the SC also has relatively high values of at least 50 percent. On the other hand, the global environmental, financial and real sector indices have less predicting power for capital flow crisis. The relative poor performance of the financial and real sector variables shows that many crises in capital flows may not be sufficiently explained by only fundamental variables but are better predicted by some pushing factors originating from abroad. However, these indices should still be considered but need to be further improved by identifying more significant indicators of those sectors. In Indonesia and Thailand, while all the indices are good indicators, the financial and global indices fall behind the other indices. The financial and real sector indices perform poorly in Korea compared to the other indices while in Malaysia and the Philippines, the global environmental and real sector indices also perform poorly.

3.2.3 EWS Operation

The actual management and operation of the EWS needs more practical criterion and detailed analysis. For example, if the CI of Indonesia crosses above the 95 percentile and issues a warning signal, then a crisis is likely to happen within a year with a 83 percent probability and there may be insufficient time to prepare and pre-empt an adverse movements in capital flows. We should examine the movements in capital flow more carefully in relation to the CI and its related economic variables even before the CI rises to the optimal threshold set up to evaluate the predictability of the CI. In other words, we should be alert to a high CI before it is close to its critical threshold. For this purpose, the conditional probability of crisis is analysed in more detail at different ranges of CI values.

The CI is broken down into four stages for which the conditional probabilities have distinct values, and hence, different measures should be considered to pre-empt capital flow movements. Table 10 shows the conditional probability of different stages of the CI for each country. First, if the CI is in the stage of "tranquil range," the probability of a crisis happening within one year is zero. Thus when the CI is at this range, no immediate measure needs to be taken.

Second, when CI is at the range of "attention range", the conditional probability of a crisis occurring is between 5 and 11 percent. At this range, the movements of capital flows and the involved financial markets need to be carefully monitored. More discretionary measures may be needed after a thorough analysis of the economic situation of each country. Thirdly, if the CI falls in the "warning range", a crisis will occur within a year with a probability of more than 30 percent. In this case, the authorities should closely monitor capital flows and the involved markets, and consider and prepare more direct measures to prevent capital flows from moving abruptly and adversely. The sectoral indices and individual indicators should also be examined carefully in order to assess and understand the vulnerable sectors and related problems. Finally, if the CI crosses the "crisis range," and a crisis in capital flows is almost sure to happen within a year, measures to

Table 10
Stages of CI Movements

Country	Class	Range	Conditional Probability
Indonesia	Tranquil	CI < 32	0.00
	Attention	32 < CI <= 38	0.05
	Warning	38 < CI <= 46	0.33
	Crisis state	46 < CI	1.00
Korea	Tranquil	CI < 22	0.00
	Attention	22 < CI <= 24	0.11
	Warning	24 < CI <= 34	0.30
	Crisis state	34 < CI	0.75
Malaysia	Tranquil	CI < 22	0.00
	Attention	22 < CI <= 30	0.05
	Warning	30 < CI <= 38	0.50
	Crisis state	38 < CI	1.00
Philippines	Tranquil	CI < 22	0.00
	Attention	22 < CI <= 29	0.11
	Warning	29 < CI <= 35	0.29
	Crisis state	35 < CI	1.00
Thailand	Tranquil	CI < 22	0.00
	Attention	22 < CI <= 29	0.11
	Warning	29 < CI <= 36	0.29
	Crisis state	36 < CI	1.00

minimise the effect of the adverse movements in capital flows on the economy must be considered.

Based on the ranges of the CI mentioned above, the SEG is to report some results of the EWS analysis every quarter. First, the CI and sectoral indices are computed for each country and the contributions of all the sectoral indices and individual indicators to the CI are also computed and evaluated. These indices are viewed graphically, examined in terms of historical movements, and compared with those of the other countries. Aanalysis would also be made on individual indicators that issue a warning signal for crisis in capital flows. When the CI reaches a higher level than "attention range", more in-depth analyses could be conducted and some corresponding measures could be discussed. If necessary, the SEG member countries could convene and discuss the movements of capital flows in detail.

4. Conclusion and Some Recommendations

As the SEG EWS is for capital flows, a signaling approach was applied to all the candidate variables and contagion related variables, in order to obtain some leading indicators which have some ability to issue a warning signal for capital flow crisis. More than 30 variables (including contagion related variables) passed the typical noise-signal ratio test of non-parametric EWS approach. All the selected variables were combined into a composite index and five sectoral indices. These indices were tested to determine that they have the power of predicting crisis in capital flows. The conditional probabilities of the CI in classified stages were examined and they could be used to monitor and pre-empt the adverse movements of capital flows. The report which provides a snapshot of the CI and signals of the individual indicators are to be shared among the member countries every quarter.

The EWS presented in this paper is preliminary. Firstly, the data quality and coverage continue to be improved for a more rigorous and accurate identification of a crisis in capital flows since this is the most important step to the EWS work. With more quality data, the SEG can incorporate more country experiences and cases into the model. The SEG should also consider and analyse in greater detail, the cyclical characteristics of capital flows. As usually seen in the boom and burst theory, capital tends to flow in short periods of time before outflows. As sudden stops usually come in bunches and clusters, more refinement is needed to clarify when a crisis starts and when it is over. The SEG should compare time series and chronological events and situations so as to pin point more accurately when a crisis period starts and when it ends.

The other issue is that more indicators continue to be explored and emphasis needs to be placed on some contagion proxies and political variables. For the practical purposes of the EWS, the SEG should continue to find variables that are related to the contagion process or the channel of capital flow crisis. It will be helpful for the SEG member countries to collect and share quality data related to the movements of capital flows, particularly political and social variables because capital flows are heavily influenced by the country risks and political events.

As a longer–range plan, the SEG hopes to incorporate higher frequency data, i.e., monthly data into the EWS model, in line with the objective of monitoring capital flows. The monthly model will be more timely and useful to the SEG member countries.

Finally, the EWS should be supplemented by some market data as these would provide timely information. The SEG templates already have high frequency data of many market measures. As past experiences show, many adverse movements in capital flows such as those resulting from speculative attacks are related to some distortions in market prices. Market distortions were usually preceded by rapid changes in volatility and drastic decline in liquidity. Therefore, good indicators of volatility and liquidity in the foreign exchange market can be used as a supplement to the quarterly EWS model. Volatility can be gauged by two different measures. One is a sample standard deviation based on historical time series data which has been widely used for many purposes mainly because of its simplicity. The other measure is an implied volatility, which is an expected value of future volatility, computed from the option price analysis. Even though 'expected' volatility is more informative, the problem is that many SEG member countries do not have an active option market yet. As for the liquidity measure, the average volume of transaction is normally used. The ratio of volume of transaction divided by volatility can be a helpful measure since in times of problems, transactions decline rapidly with an increased volatility. Considering that drastic change in volatility and rapid decline in liquidity imply increasing uncertainty, the SEG hopes to test some 'warning or risky zone' for the two measures in a similar way to the EWS signaling approach.[34]

34. It is difficult to practically examine changes in measures of volatility and liquidity before, and during the period of the crisis in capital flows since crisis cannot be properly defined in higher frequency than monthly. Actually, if the crisis is defined in higher frequency than monthly, then some time-series methodologies such as Markov-switching and some filtering approach will be applied and used as a supplement to the established EWS.

References

1. Cass, D. and Shell K., "Do Sunspots Matter?", ***Journal of Political Economy***, Vol. 91(2), pp. 193-227, 1983

2. Chui, M., S. Hall and A. Taylor, "Crisis Spillover in Emerging Market Economies: Interlink ages, Vulnerabilities, and Investor Behavior", ***Bank of England Working Paper***, No. 212, 2002

3. Dungey, M., R. Fry, B. Gonzalez-Hermosillo, and V. Martin, "Empirical Modeling of Contagion: A Review of Methodologies", ***The World Bank Working Paper*** WP/04/78, 2004

4. Edward, Sebastian, "Thirty years of Current Account Imbalances, Current Account Reversals and Sudden Stops", ***NBER Working Paper***, No.10276, 2004

5. Eichengreen, B. and A. Rose, "Contagious Currency Crisis: Channels of Conveyance", in *Changes in Exchange Rates in Rapidly Developing Countries,* T. Ito and A. Krueger, 1998

6. Eichengreen, B., A. Rose and C. Wyplosz, "Contagious Currency Crisis", ***Scandinavian Economic Review*** 98 (4), pp. 463-84, 1996

7. Glick, R. and Hutchison, M., "Banking and Currency Crises: How Common are Twin?", ***UCSC Dept. of Economics Working Paper*** No. 488, 2000

8. Glick, R. and Rose, A., "Contagion and Trade, Why are Currency Crises Regional?", ***Journal of International Money and Finance,*** 18, pp.603-18, 1999

9. Goldstein, M., and Reinhart, C., "Assessing Financial Vulnerability, An Early Warning System for Emerging Markets", ***Institute for International Economics,*** 2000

10. Frankel, J. and Rose, A., "Currency Crashes in Emerging Markets: An Empirical Treatment", ***International Finance Discussion Paper*** No. 534, Board of Governors of the Federal Reserve System, January 1996

11. Jacob, P.M., Kuper, G.H., and Lestano, "Financial Crisis Identification: A Survey", in *International Financial Contagion: Progress and Challenges,* M. Dungey and D. Tambakis (eds.), Oxford University Press, 2004

12. Kaminsky, G. and Reinhart, C., "The Twin Crises: the Causes of Banking and Balance-of-Payments Problems", Board of Governors of the Federal Reserve System, ***International Finance Discussion Papers*** No. 544, March 1996

13. Kaminsky, G., Lizondo, S. and Reinhart, C., "Leading Indicators of Currency Crises", ***International Monetary Fund Working Papers*** WP97/79, July 1997

14. Kim, S.H., A. Kose and M. Plummer, "Understanding the Asian Contagion", ***Asian Economic Journal***, Vol. 15 no. 2, pp. 111-138, 2001

15. Kim, W., and S. Wei, "Foreign Portfolio Investors Before and During a Crisis", ***NBER Working Paper*** No. 6968, 1999

16. Kochhar, K., P. Loungani, and M. Stone, "The East Asian Crisis: Macroeconomic Developments and Policy Lessons", ***IMF Working Paper*** No. 98.128, 1998

17. Kodres, L. and M. Pritsker, "A Rational Expectations Model of Financial Contagion", ***FEDS Working Paper*** No. 48, 1999

18. Laeven, L., Klingebiel, D. and Kroszner, R., "Financial Crises, Financial Dependence, and Industry Growth", ***The World Bank Working Paper*** 2855, 2002

19. Sachs, J. D., Tornell, A. and Velasco, A., "Financial Crises in Emerging Markets: The Lessons from 1995", ***Brookings Papers on Economic Activities***, pp 147-198, 1996

20. Sander, H. and S. Kleimeier, "Contagion and Causality: an Empirical Investigation of Four Asian Crisis Episodes", ***Journal of International Money and Finance***, Vol. 13(2), pp.171-186, 2003.

21. Tornell, A., "Common Fundamentals in the Tequila and Asian Crises", Harvard University Mimeo, 1998

22. Van Rijckeghem, C. and B. Weder, "Sources of Contagion: Finance or Trade?", ***Journal of International Economics***, 54, No.2, 2001

Appendix

Figure A.1: CI and Sectoral Indices of Indonesia

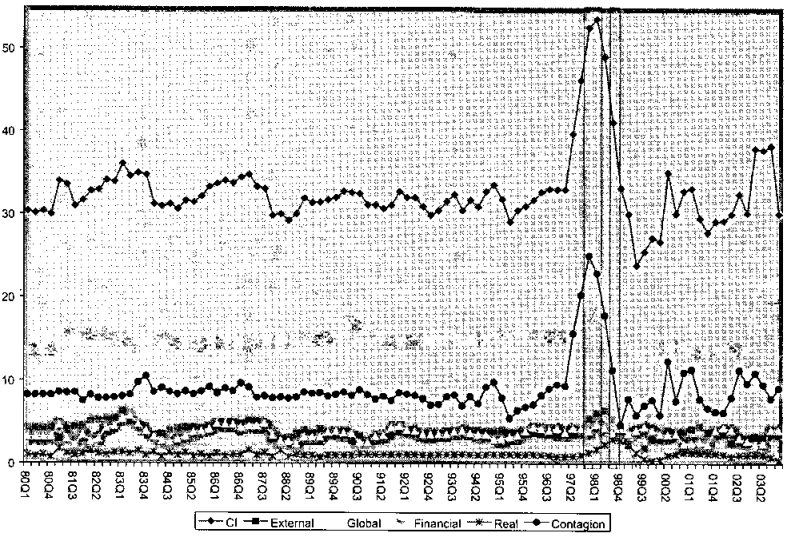


Figure A.2: CI and Sectoral Indices of Korea

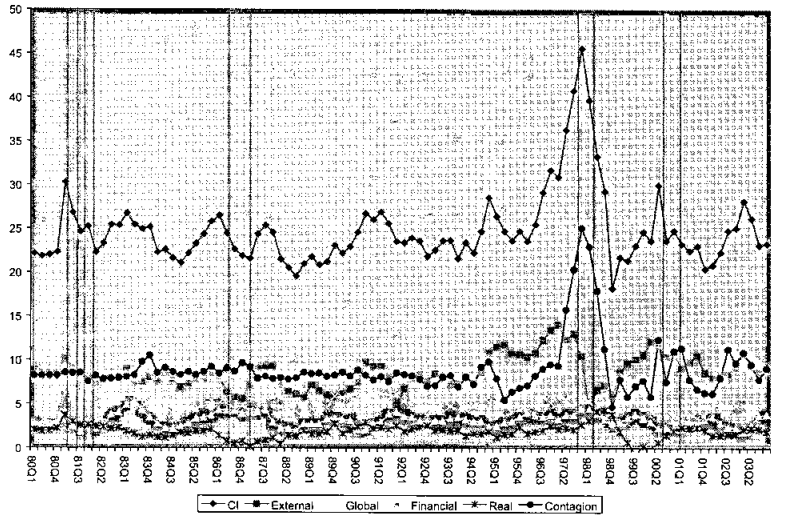


Figure A.3: CI and Sectoral Indices of Malaysia

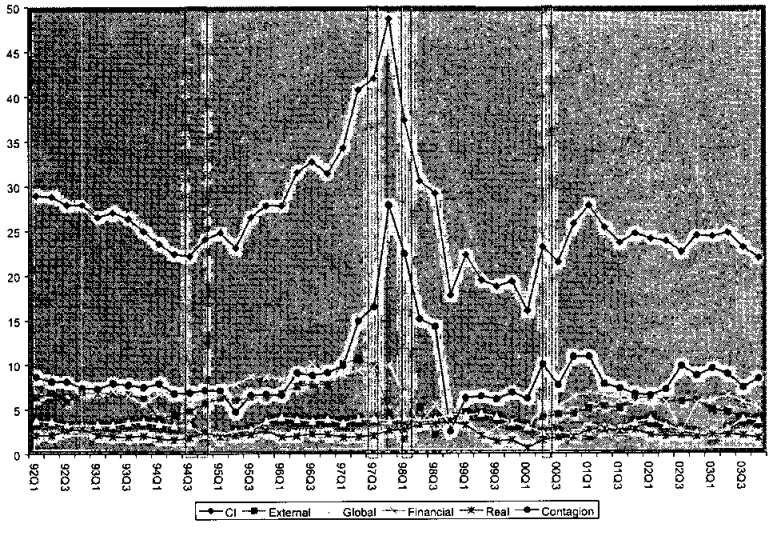


Figure A.4: CI and Sectoral Indices of Philippines

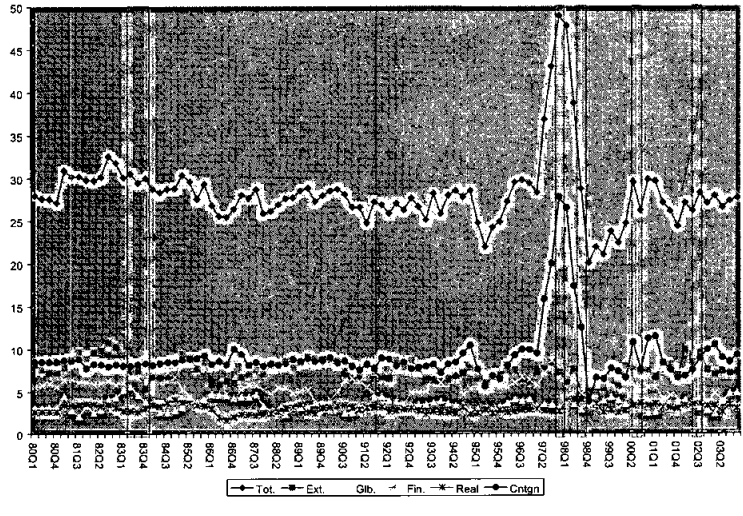


Figure A.5: CI and Sectoral Indices of Thailand

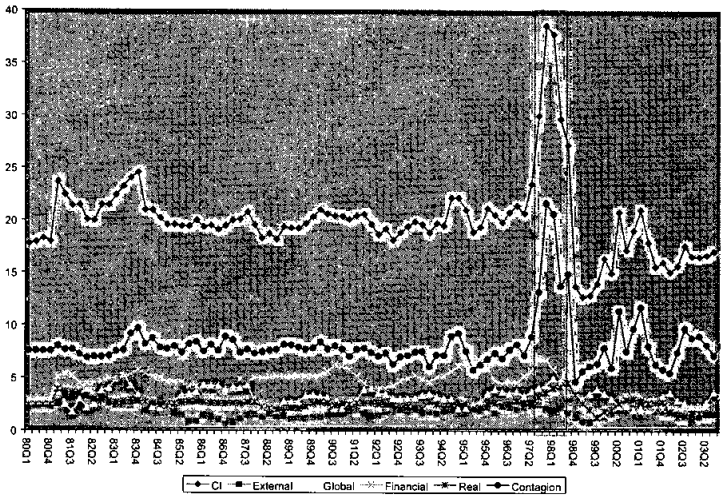


Table A.1: Sectoral Indices of Crisis in Capital Flows

Sector Index	Threshold (percentile)	Threshold (level)	Noise signal ratio	Conditional probability
Indonesia				
External Sector	92.4	5.2	0.03	0.75
Global Environment	93.5	4.7	0.29	0.25
Financial Sector	94.6	17.9	0.19	0.33
Real Sector	94.6	1.7	0.14	0.40
Contagion Effect	94.6	12.4	0.02	0.83
Korea				
External Sector	94.6	12.1	0.05	0.83
Global Environment	90.2	4.2	0.12	0.67
Financial Sector	75.0	5.2	0.69	0.25
Real Sector	87.0	2.5	0.81	0.22
Contagion Effect	93.5	10.8	0.17	0.57
Malaysia				
External Sector	94.6	7.6	0.05	0.83
Global Environment	94.6	4.4	0.69	0.25
Financial Sector	94.6	8.9	0.05	0.83
Real Sector	79.3	2.6	2.77	0.08
Contagion Effect	94.6	14.3	0.23	0.50
Philippines				
External Sector	94.6	9.6	0.00	1.00
Global Environment	76.1	4.0	0.75	0.24
Financial Sector	89.1	7.1	0.35	0.40
Real Sector	94.6	3.7	0.46	0.33
Contagion Effect	94.6	12.5	0.05	0.83
Thailand				
External Sector	89.1	2.6	0.11	0.50
Global Environment	94.6	4.3	0.11	0.50
Financial Sector	94.6	6.2	0.22	0.33
Real Sector	92.4	3.6	0.11	0.50
Contagion Effect	94.6	11.8	0.11	0.50