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TRACING AND MODELLING EXCHANGE RATE VOLATILITY IN MALAYSIA

This paper traces the presence of currency crises by adopting the exchange market pressure (EMP) index for Malaysia. Our findings confirm several signals of EMP and its impact over the sample period. Besides that, the plots of EMP index allow us witness Malaysia's quick recovery from these crises through its policy responses. These findings indicate the effectiveness of EMP index as the early warning system in detecting the market pressure of Ringgit Malaysia, especially during the episodes of crises through different exchange rate regimes.
Keywords: *exchange rate; market; Ringgit Malaysia; USD; financial crisis.*
JEL classification: F30; F31; F33; C3.

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ВІДСТЕЖУВАННЯ ТА МОДЕЛЮВАННЯ ВОЛАТИЛЬНОСТІ ВАЛЮТНОГО КУРСУ В МАЛАЙЗІЇ

У статті проаналізовано валютні кризи в Малайзії з використанням індексу напруженості валютного ринку. Результати дослідження вказують на те, що існують сигнали того, що валютна напруженість мала вплив протягом всього досліджуваного періоду. Однак побудова графіку динаміки даного індексу демонструє, що Малайзія доволі швидко відновлювалась після криз завдяки вірному валютному регулюванню. Доведено ефективність індексу напруженості валютного ринку як інструменту системи раннього попередження, особливо під час криз та за різних валютних режимів.
Ключові слова: *обмінний курс; напруженість ринку; малазійський рінггіт; долар США; фінансова криза.*
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ОТСЛЕЖИВАНИЕ И МОДЕЛИРОВАНИЕ ВОЛАТИЛЬНОСТИ ВАЛЮТНОГО КУРСА В МАЛАЙЗИИ

В статье проанализированы валютные кризисы в Малайзии с использование индекса напряжённости валютного рынка. Результаты исследования показывают, что существуют сигналы того, что валютная напряжённость имела влияние в течение всего исследуемого периода. Однако построение графика динамики данного индекса демонстрирует, что Малайзия довольно быстро восстанавливалась после кризисов благодаря правильному валютному регулированию. Доказана эффективность индекса напряжённости валютного рынка как инструмента системы раннего предупреждения, особенно во времена кризисов и при различных валютных режимах.
Ключевые слова: *обменный курс; напряжённость рынка; малазийский ринггит; доллар США; финансовый кризис.*

1. Introduction. The episodes of crises around the globe have marked intense upsurge of literature in uncovering the sources and indicators on these events for both academic and policy circles. These notable contributions have indeed enriched the empirical literature when one of major suspect was the exchange rate volatility as being the key transmission of the financial meltdown. On that account, several analytical tools have been introduced to quantify such evidence. Among the famous

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modelling tool used to capture the currency's densities is the exchange market pressure (EMP) index. The index was unveiled by Girton and Roper (1977) to assist policy makers in responding conclusively when severe compressions on currencies emerge. Evidently, EMP is a combination of information on exchange rate fluctuation, change in interest rate and reserve movement that would help policymakers understand internal and external circumstances of economy.

Being a small open and export-dependent economy, Malaysia was not spared from the economic shock and contagion effect of the currency crises under different regimes of exchange rate arrangement. For instance, in the midst of 1997, Malaysia's experiencing the Asian financial crisis following the sharp depreciation of the Thai Baht. The Ringgit dropped from about 2.57 in July to 4.88 by early 1998 against the USD (Nambiar, 2003). Unlike other Asian countries, Malaysia did not seek IMF assistance but rather introduced exchange rate peg and capital controls. The move although being unorthodox was indeed made easier by the fact that the ringgit has remained non-tradable outside at that period. By July 2005, the ringgit was de-peg where it operated in a managed float, with its value being determined by economic fundamentals.

With the 2008 sub-prime mortgage crisis in the US that lead into the worldwide crisis, the global phenomenon of high food prices, volatile commodity prices, the prolong sovereign debt crisis in Europe, the issue of currency volatility has again becoming relevant. Many notable empirical literatures (Aizenman and Hutchison, 2012) suggest that EMP index has the ability to trace crisis symptoms sufficiently that allows government and policymakers to undertake effective pre-emptive measurements.

Taking into consideration the motivation above, this paper attempts to investigate the presence of economic crises through the construction of EMP index using Malaysia as the case study. We will also trace on how this index constructed can be interpreted as an effective signalling system as it would tell us whether Ringgit Malaysia was subjected to extensiveness market pressure before, during and after the crises period. The remainder of this study is structured as follow. Section 2 provides the theoretical consideration of EMP and some relevant literature. Section 3 discusses the methodology as well as the data used in the analysis while section 4 reports the empirical findings. Lastly, Section 5 concludes.

2. Exchange market pressure: theoretical and empirical consideration. As mentioned in the previous section, the EMP concept was first coined in (Girton and Roper, 1977). This model was introduced as a monetary approach to exchange rate determination after the breakdown of the Bretton Wood[3] system (Luo and Yang, 2005). Their aim was to provide a measure of excess demand for the domestic currency and the level of the exchange rate in the absence of central bank intervention, keeping all other factors unchanged (Hall et al., 2013). During the flexible exchange era, a country's exchange rate regime was set by the foreign exchange (forex) market through which it was determined by supply and demand for that particular currency relatively to other currencies. In this sense, floating exchange rates regime changes

[3] The Bretton Woods system was an international monetary framework of fixed exchange rates after World War II and ended on August 15, 1971.

freely and is determined by trading at the forex market implying the volatile movement comparatively to the Bretton Wood regime. EMP is formulated based on the relationships between money market equilibrium and purchasing power parity (PPP) theory. This approach is based on the underlying exchange rate model also known as the model-dependent approach in literature.

We follow (Bahmani-Oskooee and Bermstein, 1997) in providing the theoretical intuition behind the EMP model. First, equilibrium at the money market requires that

$$M^d = M^s, \tag{1}$$

where M^d is the demand for nominal balances and M^s is the supply of nominal money. In return the demand for and supply of nominal money is outlined by Equations (2) and (3):

$$M^d = kPY; \tag{2}$$

$$M^s = m(R + D), \tag{3}$$

where P is the domestic price level; Y is the real output; m is the money multiplier; $(R + D)$ is the monetary base (R as net foreign assets is the foreign component of the monetary base and D as the domestic credit is the domestic component). Then, to derive the EMP model we formulate the PPP theory as in Equation:

$$E = P^* = P, \tag{4}$$

where E[4] is the spot exchange rate; P^* is the foreign price level; P is the domestic price level. By substituting Equations (2) and (3) into 1 yields:

$$kPY = m(R + D). \tag{5}$$

Next we substitute for P its equivalent from Equation (4), i.e., $P^* = E$. Thus, we have

$$k(P^* = E)Y = m(R + D). \tag{6}$$

If we assume the fraction of nominal income people hold in the form of cash, i.e., k to be constant, Equation (6) could be rewritten in the form of percentage changes as

$$p^* - e + y = a + r + d, \tag{7}$$

where p^* is the percentage change in the foreign price level; e is percentage change in E; y is the percentage change in Y; a is the percentage change in m; $r = \Delta R = (R + D)$; $d = \Delta D = (R + D)$. 1 Rearranging the terms in Equation (7) results in the exchange market pressure model as below:

$$r + e = p^* + y - a - d. \tag{8}$$

Equation (8) states that for a given p^*, y and a, an increase in domestic credit creation d will result in a one-to-one decrease in foreign reserves and an equal proportionate depreciation of domestic currency.

In order to decide the amount of pressure been captivated either by e and r, Girton and Roper (1977), Connolly and Silveira (1979) and Bahmani-Oskooee and Shiva (1998) recommend to comprise a variable $Q = (e - 1) = (r - 1)$ in the right-

[4] In this case, E is defined as number of units of foreign currency per unit of domestic currency.

hand side of Equation (8). If more of the pressure is absorbed by exchange rate depreciation relative to loss of reserves, Q will carry a significant and positive coefficient, while a significant and negative Q implies more pressure is absorbed by the loss of reserve. However, insignificant coefficient indicates monetary authority is unresponsive to the components of EMP.

$$r + e = p^* + y - a - d + Q. \quad (9)$$

Over time, this model has been modified, with weights assigned to each EMP component (Weymark, 1995; Eichengreen et al., 1996; Sachs et al., 1996; Kaminsky et al., 1998) to improve the basic model of (Girton and Roper, 1977). These authors shared similar opinion on the inclusion of interest rate as the third necessary component for the modelling and computation of the EMP index. Eichengreen et al. (1996) argued that the interest rate hikes were also central bank's response to speculative attacks. The idea here is that, since interest-rate hikes have been part of central banks' responses to speculative attacks, interest rates are one way of capturing pressures at the foreign-exchange market. By incorporating these three components (exchange rate, international reserves and interest rate) into a single index it is often termed as a model-independent approach; most widely-used method, reflecting its potential ability to capture specific factors affecting the currency pressure. This model incorporates weights to standardize the variances of each component instead of using conversion coefficients.

Looking into the empirical literature, the model has been applied to a wide range of countries, with most studies focusing on the bilateral exchange rate against the USD. For instance, Sireger et al. (2010) examine the evidence of local currency against USD and its severity during the sub-prime crisis of 2007–2009 of the South East Asia Central Banks (SEACEN) countries. Their findings suggest that SEACEN countries were affected by the sub-prime crisis and the demise of Lehman Brothers had left most of Asian currencies under severe depreciations especially the Malaysian ringgit, the Thai baht, the Korean won, the Indonesian rupiah and the Singapore dollar. Bertoli et al. (2010) suggests that the existing EMP-based crisis indicators may not be well suited for the study of currency crises in emerging countries, as they lead to a questionable selection of crisis episodes and suggests that emerging countries are much less crisis-prone than developed ones. Recently, Teh (2013) analyzed the EMP in Malaysia and examine how Bank Negara Malaysia (BNM) handles different EMP in relation to that of its two major trading partners – namely, Japan (RM/YEN exchange rate) and the United States (RM/ USD exchange rate). They found that the prescription of traditional theory was not followed by Malaysia in different EMP models throughout different exchange rate regimes.

We do acknowledge the limitation of adopting any single EMP measurement (like most the literature cited above) especially in the identification of crisis episodes which is also portrayed (Pontines and Siregar, 2008; Bertoli el al., 2010). In what follows, this paper adopt the arrays of measurements by Weymark (1995), Eichengreen et al. (1996), Sach et al. (1996) and Kaminsky et al. (1998) for Malaysia. This would provide a much clearer picture on the extent of EMP in Malaysia promoting the consistency of empirical results for prudent policy.

3. EMP measurements and data description. According to Siregar et al. (2010) and McFarlene (2010) the arrays of EMP measurements proposed by Eichengreen et

al. (1994), Weymark (1995), Sach et al. (1996) and Kaminsky et al. (1998) are much suitable in fully capturing the periods of currency crisis as they provide information on speculative pressure on a currency. In this paper, the US is used as the reference country. The arrays of EMP measurements adopted in this paper are as follow:

3.1. Eichengreen et al. (1996). The exchange market pressure index of Eichengreen et al. (1996) [$EMP_{E,t}$] is expressed as:

$$EMP_E = \frac{1}{\sigma_e}\left(\frac{\Delta e_t}{e_t}\right) - \frac{1}{\sigma_r}\left(\frac{\Delta r_t}{r_t} - \frac{\Delta r_{US,t}}{r_{US,t}}\right) + \frac{1}{\sigma_i}\left[\Delta\left(i_t - i_{US,t}\right)\right], \quad (10)$$

where e_t is the unit of a country currency per USD in period of t; r_t is the international reserves; $r_{US,t}$ indicates international reserves for the US; i_t and $i_{US,t}$ are the domestic interest rate and US interest rate in the period of t respectively. Meanwhile, the parameter of σ_e is the standard deviation (SD) of the relative change in the exchange rate $\left(\frac{\Delta e_t}{e_t}\right)$; σ_r is the SD of the difference between relative changes in foreign reserves at home and in the reference country $\left(\frac{\Delta r_t}{r_t} - \frac{\Delta r_{us,t}}{r_{us,t}}\right)$; σ_i stands for the SD of the nominal interest rate differential ($i_t - i_{US,t}$).

3.2. Weymark (1995) expressed [$EMP_{W,t}$] as below:

$$EMP_{w,t} = \frac{e_t - e_{t-1}}{e_{t-1}} - \xi\left(\frac{r_t - r_{t-1}}{Money}\right) + \vartheta\Delta\left(i_t - i_{US,t}\right), \quad (11)$$

where e_t represents the unit of a country currency per USD in the period t; $Money$ represents a narrow definition of money supply; r_t is international reserves, while i_t and $i_{US,t}$ indicate as the nominal interest rate and US nominal interest rate respectively. The parameter of ξ is the SD of the relative change in the exchange rate to the SD of international reserve changes and ϑ represents the ratio of SD of exchange rate changes to the SD of changes in the interest rate differential.

3.3. Sachs et al. (1996). The exchange market pressure index of Sachs et al. (1996) [$EMP_{S,t}$] is expressed as follows:

$$EMP_{S,t} = \frac{\frac{1}{\sigma_e}}{\left(\frac{1}{\sigma_e} + \frac{1}{\sigma_r} + \frac{1}{\sigma_i}\right)}\left(\frac{\Delta e_t}{e_t}\right) - \frac{\frac{1}{\sigma_r}}{\left(\frac{1}{\sigma_e} + \frac{1}{\sigma_r} + \frac{1}{\sigma_i}\right)}\left(\frac{\Delta r_t}{r_t}\right) + \frac{\frac{1}{\sigma_i}}{\left(\frac{1}{\sigma_e} + \frac{1}{\sigma_r} + \frac{1}{\sigma_i}\right)}\left(\Delta i_t\right), \quad (12)$$

where e_t is again the unit of country currency per USD in the period t; r_t the international reserves in the period t; i_t domestic interest rate in the period t; σ_e the SD of the rate of change in the exchange rate $\left(\frac{\Delta e_t}{e_t}\right)$; σ_r – the SD of the rate of change in the reserves $\left(\frac{\Delta r_t}{r_t}\right)$; σ_i is the SD of the change in the nominal interest rate [Δi_t].

3.4. Kaminsky et al. (1998). The exchange market pressure index of Kaminsky et al. (1998) [$EMP_{K,t}$] is expressed as follows:

$$EMP_{K,t} = \frac{\Delta e_t}{e_t} - \frac{\sigma_e}{\sigma_r}\left(\frac{\Delta r_t}{r_t}\right) + \frac{\sigma_e}{\sigma_i}(\Delta i_t), \quad (13)$$

where e_t is the unit of country currency per USD in the period t; r_t – international reserves in period t; i_t – domestic interest rate in period t; σ_e is the SD of the rate of change in the exchange rate $\left(\frac{\Delta e_t}{e_t}\right)$; σ_r – the SD of the rate of change in reserves $\left(\frac{\Delta r_t}{r_t}\right)$; σ_i is the SD of the change in the nominal interest rate $[\Delta i_t]$.

Eichengreen et al. (1996), Weymark (1995), Sachs et al. (1996) and Kaminsky et al. (1998) have proposed different computations of the EMP index as shown in the Equations (10)–(13) where they have different precision weights scheme. First, Eichengreen et al. (1996) used the inverse of each component's variance as the corresponding weights to equalize the volatilities since the volatilities of reserves, exchange rates and interest differentials are very different which helps preventing any of the components from dominating the index. Furthermore, if a component has higher variance, a lower weight would be assigned to it and vice versa. Second, Weymark (1995) employs the variations of the conversion factor parameter[5] for the relative weight of exchange rate changes and intervention in the EMP index.

Third, Sachs et al. (1996) calculated each weight in the EMP index with respect to standard deviations of all components included instead of using only standard deviation of the respective component to avoid the dominance of the most volatile variable. As for Kaminsky et al. (1998), they modified the original model by (Eichengreen et al., 1996) where the interest rate differential is replaced by relevant interest rate in the country analyzed. Moreover, the weights on the reserves and interest rate terms are the ratio of the standard error of the percentage change of the exchange rate over the standard error of the percentage change of reserves and the interest rate differential respectively (Stavarek, 2007).

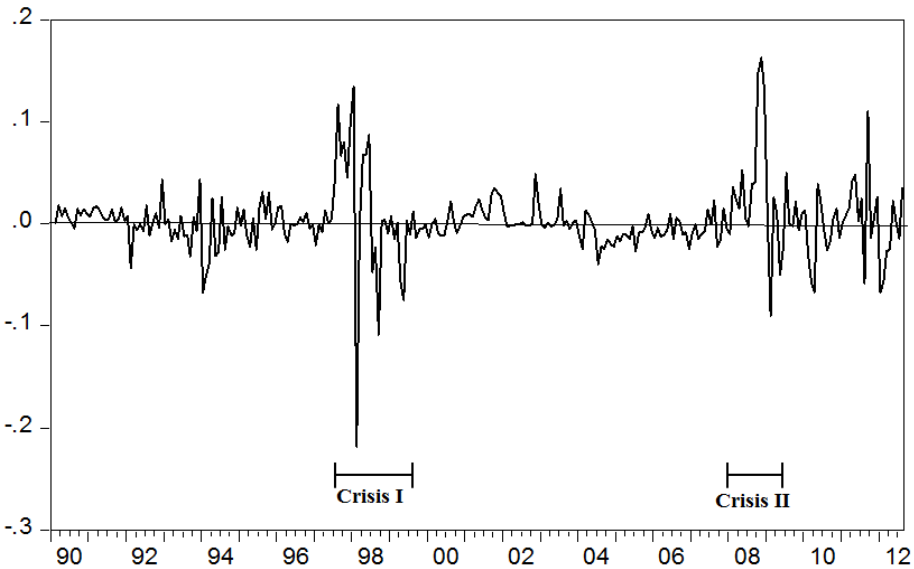
It is clear that Eichengreen et al. (1996), Weymark (1995), Sachs et al. (1996) and Kaminsky et al. (1998) do not apply equal weights in constructing the EMP index. According to Li et al. (2006), it would be incorrect to impose the same weights in measuring the EMP index since each country has different economy structure and different sensitivities of exchange rate changes with respect to interest rate and reserve changes. In this sense, the concern raised in literature would be minimized.

3.5. Data source. All the variables are monthly data (in mln USD) over the period 1990:M1–2012:M8 were obtained from the International Financial Statistics (IFS) of the International Monetary Fund (IMF). The sample period includes the fixed and managed float exchange rate regime and two major crises for Malaysia. In this paper, the US is used as our foreign counterpart.

4. Empirical results. The constructed indices of EMP are shown in Figures 1–4. They exhibit the diverging volatility and intensity of market pressure for Malaysia. There are few annotations which worth to be highlighted. First, the constructed

[5] This parameter represents the relative weight of the exchange rate changes to the intervention changes (represented by international reserve changes) in the EMP index (Stavarek, 2007).

indices of EMP for all figures dull that Ringgit Malaysia had actually been under high buying pressure in 1993, domestic currency is appreciating, with low interest rate and high foreign reserves (Siregar et al., 2010) being an indication of negative EMP. This was due to rapid globalization in the 1990s which led to miraculous economic growth experienced by our country. Besides that, Sharma (2003) claimed that the transformation of Malaysia in becoming an open economy in the 1990s had also attributed to Malaysia becoming one of the world's highly capitalized stock and open financial markets through the introduction of several important liberalization measures, including the liberation of interest rate, sharp reduction of credit controls and improvements in the legal, supervisory and regulatory framework to address prudential concerns. Obviously, positive effects of globalization had indeed strengthen Malaysian economy in becoming more integrated through equity enhancing policies (National Development Policy, 1991–2000)), trade expansion and foreign direct investment which helped the economic expansion.



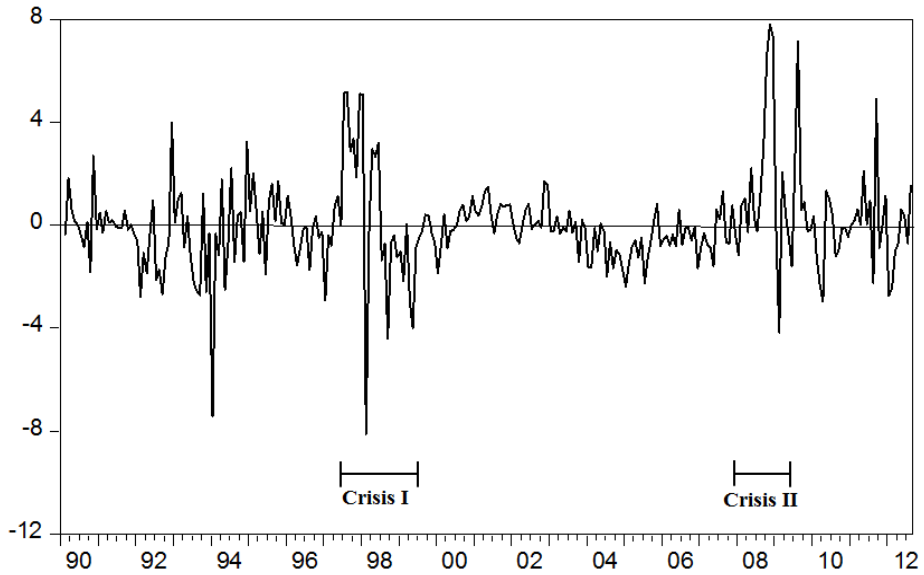
Note: Crisis I represents the period of the Asian financial crisis, Crisis II represents the period of the Subprime crisis.

Figure 1. **Weymark** (1995)

Second, it is clear that prior to 1998 all figures show that at the second quarter of 1998, EMP values reached the peak of selling pressure and by the third quarter of 1998 it was at the lowest peak of buying pressure. This was the period of managed float exchange rate regime, with domestic currency devalued, high interest rate and low foreign reserves (Siregar et al., 2010). Apparently, these sudden skyrockets in the EMP values are due to the contagious effects of the 1997 Asian financial crisis where Ringgit Malaysia was under intense speculative pressure and there were large capital outflows from the country.

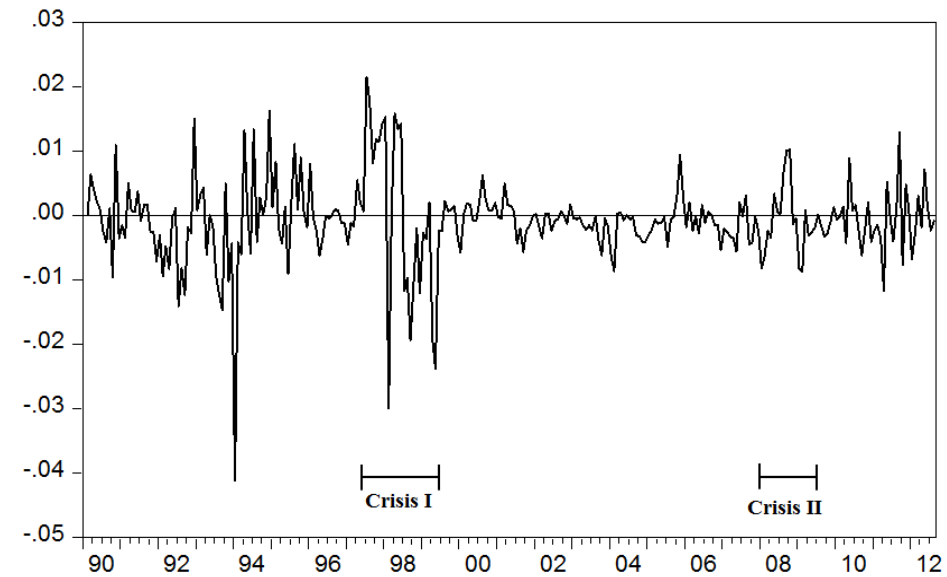
Third, Malaysia's policy responses to the crisis have indeed marked significant decrease in EMP values which later becomes relatively stable. One of the notable policy responses is the implementation of capital control when Ringgit Malaysia was pegged against USD at RM3.80. As a result, capital control has helped reduce the

outflow and inflation which later eliminate speculative pressures in domestic interest rates and exchange rates. Nonetheless, the EMP index also shows that Malaysia has much stable fluctuations during the fixed exchange regime, from 1999 to 2005.



Note: Crisis I represents the period of the Asian financial crisis, Crisis II represents the period of the Subprime crisis.

Figure 2. **Eichengreen et al.** (1996)

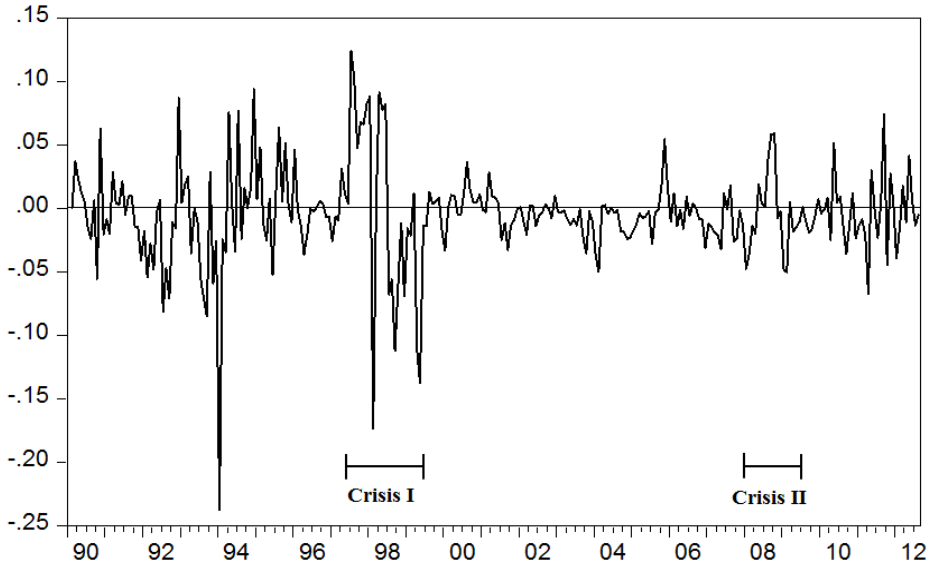


Note: Crisis I represents the period of the Asian financial crisis, Crisis II represents the period of the Subprime crisis.

Figure 3. **Sachs et al.** (1996)

These figures clearly show that there is a slight increase in the EMP values during the first quarter of 2008 (the time of Lehman Brother's collapse) which indicates

depreciation of Ringgit Malaysia. However, in 2009 the selling pressures have subsided after the government imposed two fiscal stimulus packages to recover from the full-blown recession.



Note: Crisis I represents the period of the Asian financial crisis, Crisis II represents the period of the Subprime crisis.

Figure 4. **Kaminsky et al.** (1998)

5. Conclusion. In this paper, we have constructed the EMP index and used it to trace the presence of extreme market pressures for Malaysia with the emphasis on the economic crises. The inference drawn from the 4 different index models confirm several signals of EMP especially around the crises periods. Also, one could observe Malaysia's quick recovery from these crises identified which characterized through its appropriate policy responses during turbulent times. Our findings confirm that the EMP index is an effective signaling tool due to its ability in models and tracing crisis symptoms. This would be useful for government to make effective pre-emptive measurements. Looking ahead, managing and understanding the intensity of exchange rate volatilities is indeed an important national agenda.

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