

**MEASURING CURRENCY CRISES USING EXCHANGE MARKET PRESSURE  
INDICES: THE IMPRECISION OF PRECISION WEIGHTS**

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## MEASURING CURRENCY CRISES USING EXCHANGE MARKET PRESSURE INDICES: THE IMPRECISION OF PRECISION WEIGHTS

### Abstract

Recent empirical studies of the determinants and effects of currency crises have relied primarily on the concept of exchange market pressure (EMP) proxied by some combination of changes in exchange rates, international reserves, and interest rates. It has become popular to weight these variables by the ratio of the inverse of their variance. We show that so called precision weights have no clear economic interpretation since they result from a combination of market generated volatilities and policy reaction functions. We also show that precision weights can generate substantial downward biases in the case of unsuccessful speculative attacks on pegged exchange rates. The theoretically correct weights are shown to be a function of relative elasticities in the foreign exchange market. Since good estimates of these are not available for large samples of countries, one alternative is to involve the principle of equal ignorance and assign equal weights.

*Keywords:* Currency crisis, Devaluation, Exchange Market Pressure (EMP) index, Interest rate hike, Reserves, Speculative attacks.

*JEL Classification:* E4, F3, F4.

## 1. Introduction

In recent years there has been a marked increase in interest in the study of currency crises. This in turn has generated considerable work on the construction of measures of currency crises suitable for quantitative research. The most dramatic form of a currency crisis is a drastic depreciation of a currency termed a “currency crash” by Frankel and Rose (1996). Measures of currency depreciation, however, only capture crises and speculative attacks that are “successful”, i.e. those that lead the monetary authority to forsake the pegged exchange rate with consequent depreciation of the currency. There are, however, many instances of speculative attacks that are unsuccessful. A well known one is the case of Hong Kong in 1997-98 in which the Hong Kong Monetary Authority (HKMA) maintained its US dollar-based currency board arrangement despite intense and sustained speculative attacks on the currency via sharp interest rate hikes. Other countries have defended their currencies against bearish pressures by allowing a drain in reserves (Argentina 1995 is one of many cases in point).

In order to capture such “unsuccessful” currency attacks, economists have developed a so-called “exchange market pressure” (EMP) index which is a composite variable incorporating at least two of the following three variables, viz. the exchange rate, international reserves and interest rates. The pioneering effort in the development of an EMP index is by Girton and Roper (1977) who developed an index combining exchange

rate depreciation with reserve changes.<sup>1</sup> While Eichengreen et al. (1994) correctly argued that the interest rate hikes were the central banks' response to speculative attacks as well and should be included in the computation of the EMP index, early studies of crises in developing countries excluded the interest rate variable due to lack of internationally comparable market determined interest rates. Kaminsky and Reinhart (1999), Edison (2003), and Glick and Hutchison (2001) also developed and used a two variable EMP index without interest rates. However, Bordo (2001), Bussière and Fratzscher (2002) and Nitithanprapas and Willett (2000) included all three variables to construct the EMP index and this has now become common.<sup>2</sup>

The exclusion of any one of the variables of course implicitly implies a zero weight placed on it. But what is the weighting scheme to be used for the variables that are included in the EMP index. This has remained a subject of some controversy. For instance, Girton and Roper (1977), based on the use of a monetary model, weighed exchange rates and reserve changes equally. In contrast, Eichengreen et al. (1994, 1995) recognized that the relatively large volatility of one component might dominate the movement of the EMP index. In view of this they developed and used the so-called "precision weighting scheme" (also called "variance-weighted scheme") in which the

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<sup>1</sup> Instead of using reserve levels data, Tanner (2001) used the ratio of reserves and base money as the second component of the EMP index. For a survey of the literature on measuring currency crises, see Angkinand et al (2006).

<sup>2</sup> Interestingly, Pankki (1999) includes the change of domestic credit as the third component instead of interest rates. The author argues that if the exchange rates are held fixed, changes in foreign reserves and domestic credit would reflect the size of external imbalance. Thus, sterilization should be taken into account in the EMP index as well.

inverse of each component's variance served as the weight in constructing the EMP index. By so doing, the precision weighting scheme equalized the volatilities of the changes in exchange rates, reserves, and/or interest rates. This has become the most commonly used approach. In a series of papers, Weymark (1995, 1997, 1998) developed a third weighting scheme called the "elasticity approach" which is derived from a structural model of how the exchange rate should change in response to one percentage change in reserves in order to keep the money market equilibrium.

Nitithaprapas and Willett (2000) and Willett et al (2005) argued that since the relative variances of the crisis index variables reflect policy reaction functions as well as market determined, the use of precision weights is not appropriate. In fact, Eichengreen et al (1994) pointed out that the appropriate weighting should be by elasticities, but since there are generally not available, they used precision weights. Nitithanprapas and Willett (2000) and Willett et al (2005) recommend that in the absence of knowledge of the relevant elasticities, equal weights be used in recognition of our ignorance. They also note that relative elasticities are likely to change during crises and recommend checking whether conclusions are sensitive to alternative weighting schemes.

In summary, in the recent literature there has been a wide array of EMP indices using various combinations (i.e. at least two) of the three variables with different weighting schemes. This paper critically reviews and compares the different weighting schemes used in constructing EMP indices. Particular emphasis is placed on a critical analysis of the precision weights which has become the most widely used of the weighting schemes.

The remainder of this paper is organized as follows. Section 2 extends the model in Weymark (1995) to include interest rate fluctuations in constructing the EMP index. Section 3 discusses the inappropriate use of precision weights scheme, and shows that they will substantially understate the strength of unsuccessful speculative attacks against fixed exchange rate regimes. Section 4 concludes the paper.

## **2. Revisiting the Weymark (1995) Model**

Weymark (1995) focused on the issue of weights assigned to each component of the EMP index. The author utilized a small open economy model to track the exchange rate elasticity of reserve changes and used it as the weight in constructing two-component EMP index. In so doing, she converted the percentage change of reserves into the equivalent percentage change of the exchange rate. To be specific, Weymark (1995) defined the EMP as follows:

EMP measures the total excess demand for a currency in international markets as the exchange rate change that would have been required to remove this excess demand in the absence of exchange market intervention, given the expectations generated by the exchange rate policy actually implemented (p.278).

We adopt the basic framework of Weymark (1995) but extend the concept of the EMP index from two components as used originally (exchange rate changes and reserves changes) to include interest rate changes. The EMP index indicates the magnitude of the exchange rates changes that would have occurred if the monetary authority did not

intervene the market using the policy tools of reserves and interest rates. In order to compare the results with Weymark (1995), the notations adopted in this study are consistent with Weymark (1995) wherever possible.

## 2.1 The Model

The model is a small open economy model in which the domestic price level is influenced by both the level of foreign prices and the exchange rate. The domestic output is determined by interest and exchange rates among other factors. The foreign price level is exogenous. Domestic residents hold domestic currency for transactions purposes as well as speculative balances of foreign claims.

$$m_t^d = p_t + b_1 y_t - b_2 i_t + v_t . \quad (1)$$

$$p_t = a_0 + a_1 p_t^* + a_2 e_t . \quad (2)$$

$$y_t = c_0 - c_1 i_t + c_2 e_t + c_3 X_t . \quad (3)$$

$$m_t^s = m_{t-1}^s + \Delta d_t + \Delta r_t . \quad (4)$$

where:  $m_t$  = the logarithm of the money stock in period t with the superscripts s and d denoting supply and demand, respectively;  $p_t$  = the logarithm of domestic price level in period t;  $y_t$  = the logarithm of real domestic output in period t;  $i_t$  = the logarithm of the domestic interest rate level in period t;  $v_t$  = the stochastic money demand disturbance in

period  $t$ ;  $e_t$  = the logarithm of the period  $t$  exchange rate expressed as the domestic currency cost of one unit of foreign currency;  $X_t$  = the logarithm of the determinants of real domestic output other than  $i_t$  and  $e_t$ . In addition,  $\Delta d_t = [h_t D_t - h_{t-1} D_{t-1}] / M_{t-1}$ , where  $h_t$  is the money multiplier in period  $t$ ,  $D_t$  is the stock of domestic credit, and  $M_{t-1}$  is the inherited money stock in period  $t$ .  $\Delta r_t = [h_t R_t - h_{t-1} R_{t-1}] / M_{t-1}$ , where  $R_t$  is the stock of foreign exchange reserves in period  $t$ . All coefficients are assumed to be positive.

Equation (1) is a domestic money demand function which is defined in the conventional manner. Equation (2) derives the domestic price level from the purchasing power parity (PPP). Thus, higher foreign prices or a depreciated domestic currency will boost the domestic price level. Equation (3) is essentially the IS curve, whereby the domestic income is a function of the interest rates, the exchange rates as well as other factors. Equation (4) describes the evolution of domestic money supply; it depends on changes in domestic credits and reserves.

Substituting equations (2) and (3) into (1) reveals that the demand for money is determined by:

$$m_t^d = a_0 + a_1 p_t^* + a_2 e_t + b_1 [c_0 - c_1 i_t + c_2 e_t + c_3 X_t] - b_2 i_t + v_t. \quad (5)$$

Rewriting Equation (4) in deviation form as:

$$\Delta m_t^s = m_t^s - m_{t-1}^s = \Delta d_t + \Delta r_t . \quad (6)$$

Under the assumption that the money market clears continuously (i.e.  $m_t^d = m_t^s = m_t$ ), together with equations (5) and (6), allows the money market equilibrium to be expressed in deviation form as:

$$\Delta e_t = \frac{\Delta r_t + (b_1 c_1 + b_2) \Delta i_t + \Delta d_t - a_1 \Delta p_t^* - b_1 c_4 \Delta X_t - u_t}{a_2 + b_1 c_2} . \quad (7)$$

Equation (7) indicates that the change in the value of the exchange rate in the small open economy is given by:

$$\Delta e_t = \beta \Delta r_t + \gamma \Delta i_t + W_t . \quad (8)$$

where:  $W_t = [\Delta d_t - a_1 \Delta p_t^* - b_1 c_3 \Delta X_t - u_t] / [a_2 + b_1 c_2]$ . This variable represents a combination of factors other than interest rates and reserves that influence the change of exchange rates while keeping money market equilibrium.  $\beta = \partial \Delta e_t / \partial \Delta r_t = [a_2 + b_1 c_2]^{-1}$  is the elasticity which converts observed reserve changes into equivalent exchange rate units.  $\gamma = \partial \Delta e_t / \partial \Delta i_t = [b_1 c_1 + b_2] / [a_2 + b_1 c_2]$  is the elasticity which converts observed interest rate changes into equivalent exchange rate units.

Note that both  $\beta$  and  $\gamma$  are positive. As  $\Delta r_t > 0$ , the money supply increases. The domestic currency must depreciate to boost the domestic price, which in turn increases domestic money demand and consequently restores money market equilibrium. Similarly, when domestic interest rates rise the money demand decreases. The domestic currency has to depreciate to boost the money demand in order to restore money market equilibrium.

The EMP index can be defined as:

$$EMP_t = \Delta e_t - \beta \Delta r_t + \gamma \Delta i_t. \quad (9)$$

This index demonstrates what the exchange rate changes would have been if the authority did not intervene in the exchange market or increase the interest rates to defend domestic currency. In particular, the depreciation of domestic currency, and loss of international reserves as well as the hikes of domestic interest rates will increase the EMP index.

## 2.2 The Constraints for the Equal Weighting Scheme

The precision weighting scheme disregards the analysis of the weights just presented. On the contrary, the equal weights scheme might be consistent with the elasticity analysis if certain conditions are met. Making the equal weights consistent with the methodology described above we obtain:  $\beta = \gamma = 1$ . If  $\beta = 1/[a_2 + b_1 c_2] = 1$ , and  $\gamma = [b_1 c_1 + b_2]/[a_2 + b_1 c_2] = 1$ , then

$$a_2 + b_1c_2 = 1. \quad (10)$$

$$a_2 + b_1c_2 = b_1c_1 + b_2. \quad (11)$$

Equation (10) describes the constraint with which the one percentage change of reserves enters the EMP index equally as a one percentage change of exchange rates. Equation (11) shows the conditions under which a one percentage change of interest rates would have the same impact on the EMP index as the one percentage change of exchange rates. As first noted by Nitithanprapas and Willett (2000), the equal weighting scheme might be a second-best choice if we cannot easily apply the elasticity approach to a large set of countries. As long as the constraints given by equations (10) and (11) hold, the equal weighting scheme is consistent with the approach we just presented. The interpretations of the two constraints can be more easily seen by rearranging equation (5):

$$m_t^d = (a_2 + b_1c_2)e_t - (b_2 + b_1c_1)i_t + [a_0 + a_1p_t^* + b_1(c_0 + c_3X_t) + v_t]. \quad (12)$$

where:  $(a_2 + b_1c_2)$  is the coefficient of domestic exchange rates in money demand function. It measures the extent to which the domestic money demand responds to exchange rates.

Equation (1) shows that there are two channels through which the exchange rates have an impact on the money demand. One is the domestic price, while the other is

domestic income.  $a_2$  captures the effect of exchange rates through the first channel.  $b_1c_2$  gauges the effect is via the second channel. If the combined effects  $(a_2 + b_1c_2)$  are equal to unity, then  $\beta$ , as the inverse of the total effects, equals one as well. Alternatively, if a unit increase in  $e_t$  boosts the domestic money demand by exactly one unit then the reserves elasticity of exchange rates  $\beta$  equals one as well.

In equation (12),  $(b_1c_1 + b_2)$  is the absolute value of the coefficient of  $i_t$ , which picks up the total effects on money demand from interest rates. There are also two ways for interest rates to affect domestic money demand: a direct one and an indirect one. Interest rates enter the money demand function directly with the magnitude of marginal effect given by  $b_2$ . They can also have an impact on money demand through the channel of domestic income ( $y_t$ ) by a magnitude of  $b_1c_1$ .

Note that if equations (10) and (11) hold for the equal weighting scheme, the money demand function (equation 12) will show a very unique structure:

$$m_t^d = e_t - i_t + [a_0 + a_1 p_t^* + b_1(c_0 + c_3 X_t) + v_t]. \quad (13)$$

Equation (13) equalizes the total effects on the domestic money demand from exchange rates with the total effects from interest rates. It defines a special case which justifies the use of equal weights in the EMP index.

Combining equations (10) and (11) allows us to derive the condition under which the weights assigned to each component in the EMP index are equal:

$$a_2 + b_1c_2 = b_1c_1 + b_2 = 1. \quad (14)$$

Equation (14) ensures that the money market disequilibrium from one percentage change in exchange rates can be eliminated from either a one percentage change in reserves or a one percentage change in interest rates. Equation (14) is clearly a strong assumption for applying equal weights to constructing the EMP index. The important point, however, is that the equal weight scheme might be consistent with the elasticity approach under certain situations.

Basically, the observed combination of exchange rate changes, reserve changes and interest rate changes describes the policy response function of the monetary authority. Depending on the structure of its economy, each country has its own sensitivities of exchange rate changes with respect to interest rates and reserve changes. Accordingly, it would be incorrect to impose the same weights to the different countries to measure the EMP index. Even for the same country, the sensitivity might be time-varying as well. Thus, even though we derived the two exchange rate elasticities of reserve changes and interest rate changes in Section 3, it is still a difficult task to implement in practice because of the difficulties of estimation.

#### **4. Precision Weights and their Problems**

As noted, Eichengreen et al (1994, 1995) proposed using the inverse of each

component's variance as the corresponding weights. Their proposal was based on the observation that the conditional volatility of percentage changes in reserves is several times the percentage change in the exchange rate, which itself is several times the percentage change in the interest rate differential. The precision weights were designed to equalize the weights of the three components so that no one component would dominate the movement of the EMP index. Therefore, if a component has higher variance, a lower weight would be assigned to it. In the meantime, a component with a lower variance would gain a higher weight. The use of precision weights has become widely used in the literature.<sup>3</sup>

Willett et al. (2005) and Nitithanprapas and Willett (2000) argued that this form of weighting is correct for building a composite variable with variables freely determined in markets (such as stock prices or bond yields), but that in constructing the EMP index, all three components are considered policy variables whose volatilities reflect at least in part the authority's preferences for policy strategies. Thus, the greater variance of reserves does not necessarily mean the volatility of reserves itself is large. This might reflect that the monetary authority tends to intervene more in the exchange market by buying or selling reserves instead of letting the exchange rate float. Therefore, it may be inappropriate to discount reserve changes more than exchange rate changes in

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<sup>3</sup> For applications, see Kaminsky and Reinhart (1999), Bubula and Otker-Robe (2003), Bordo, et al. (2001), Edison (2003), Glick and Hutchison (2001), Berg and Pattillo (1999), Aziz, et al. (2000), Bussière and Fratzscher (2002), Galindo and Maloney (2002), Sachs, et al. (1996), Bussière and Mulder (1999),

constructing the EMP index.

Ideally, one should strip out the reserve volatility caused by the free market and retain the policy part of the volatility.<sup>4</sup> Based on the elasticities we computed in Section 3, one can convert the policy part of the reserve volatility into the equivalent percentage changes of exchange rates which will be added up to the original percentage changes in exchange rates to derive the EMP index. In algebraic terms, we should be able to decompose the volatility of reserve changes into two parts:  $\sigma_R = \sigma_{R,M} + \sigma_{R,P}$ , where  $\sigma_R$  represents the total volatility of reserve changes;  $\sigma_{R,M}$  is the part of the volatility determined by free market; and  $\sigma_{R,P}$  is the policy part of volatility caused by the monetary authority's intervention.

In the precision weight scheme,  $\sigma_{R,P}$  is assumed to be zero, while  $\sigma_{R,M}$  is assumed to be equal to  $\sigma_R$ . However, in the equal weighting scheme, the three components are taken as the complete policy tools, thus the total volatility  $\sigma_R$  is equal to  $\sigma_{R,P}$ . In practice it is very difficult to distinguish the two parts (market versus policy) except in the extremes of pure fixes and pure floats. All that can be said is that if  $\sigma_{R,P}$  is closer to  $\sigma_R$ , then it is more reasonable to assume  $\sigma_{R,M}$  as zero, and vice versa.

As noted previously, reserve changes are better regarded as an intervention policy tool, especially in a pegged exchange rate regime. Under a completely free float there

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<sup>4</sup> In a perfect world, there should not be any volatility in reserves. All the surplus and deficit in the balance of payment should be eliminated by the instantaneous exchange rate movement. However, the exchange rate response to the balance of payments is delayed in reality so that the monetary authority has to maintain some position of reserves. Since the purpose of constructing the EMP index is to capture the market pressure from speculative attacks, any reserve volatility due to the factors other than speculative attacks can be regarded as market-determined volatility.

would be no intervention and any reserve changes would reflect other factors such as interest earnings. In reality, however, most floats are managed via exchange rate interventions so as to avoid perceived excessive exchange rate fluctuations. In this respect, the greater variability of reserve changes reflects the authority's preference in using reserves to reduce exchange rate variability. Thus, a technically precise EMP index should not discount the effect of reserve changes by imposing a smaller weight on it. In fact, in a completely fixed regime, the entire weight should be given to reserve changes to measure the EMP index since reserves are the only variable allowed to fluctuate.<sup>5</sup> The next subsection demonstrates this point more formally.

#### **4.1 The EMP Index under a Completely Fixed Exchange Rate Regime**

This subsection demonstrates the appropriate combination of the different components in the EMP index under a complete fixed exchange rate regime. Under such a regime, there is, by definition, no change in the nominal exchange rates. Thus, the number of components in the EMP index is naturally reduced from three to two. Notice that a one percentage change in interest rates is not necessarily equivalent to a one percentage change in reserves in constructing the two-component EMP index as suggested in the equal weights scheme. The real relationship between these two should be traced out by adapting the original model (equations 1 to 4) in section 2 to the case with

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<sup>5</sup> Of course this problem would be less if the weights were based on variances from the whole set of countries being considered as is done in some studies. Pooling the variances, however, doesn't eliminate the basic problem of the lack of a clear economic meaning for this weight.

two components.

Keeping the exchange rate constant, equation (2) can be modified as:

$$p_t = \hat{a}_0 + a_1 p_t^* \quad \text{where} \quad \hat{a}_0 = a_0 + a_2 \bar{e}. \quad (15)$$

Similarly, equation (3) can be rewritten as:

$$y_t = \hat{c}_0 - c_1 i_t + c_3 X_t \quad \text{where} \quad \hat{c}_0 = c_0 + c_2 \bar{e}. \quad (16)$$

Therefore, equations (1), (15), (16), and (4) constitute a new system under the fixed rate regime. Following the similar steps described in the last section we are able to derive the following:

$$\Delta r_t = \phi \Delta i_t + Z_t. \quad (17)$$

where:  $\phi = b_1 c_1 + b_2 = \gamma / \beta$  and  $Z_t = a_1 \Delta p_t^* + b_1 c_3 \Delta X_t - \Delta d_t + \Delta v_t$ .  $\beta$  and  $\gamma$  are defined in equation (8).

Thus, the revised definition for the EMP index is:

$$EMP_t = \Delta r_t + \phi \Delta i_t. \quad (18)$$

In equation (18),  $\phi$  is the reserve elasticity of the interest rate, which measures the percentage changes of reserves needed in response to a one percentage change of interest rates in order to maintain money market equilibrium. This will be a function of the degree of international capital mobility. By applying  $\phi$  to the weight of the percentage changes in interest rates in the EMP index we can convert the changes of interest rates into the equivalent changes in reserves to maintain money market equilibrium.

Note that  $\phi$  is simply the relative weight of  $\beta$  and  $\gamma$  defined in equation (8). Equation (18) contrasts with the precision weights scheme in terms of all three weights. Under a pure fixed exchange rate regime, the precision weights scheme gives complete weight to exchange rate changes, while equation (18) gives zero weight to exchange rate changes. Due to the zero volatility in exchange rates, the weights for reserve changes and interest rate changes approach zero in precision weights scheme.<sup>6</sup> However, the weights are 1 and  $\phi$  respectively in this elasticity approach. This is the reason why the precision-weighted EMP index cannot capture the speculative market pressure with unsuccessful attacks in a fixed exchange rate regime. Such an index underestimates the actual exchange market pressure quite substantially. The conceptually correct way to catch the exchange market pressure in fixed regime is to look at the changes in the other two components.

Consider the examples of the unsuccessful speculative attacks on Argentina in 1995

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<sup>6</sup> Of course most fixed exchange rate regimes allow fluctuations within a narrow band. For convenience we treat only the limiting case where the band is zero.

and Hong Kong in 1998.<sup>7</sup> During the Tequila crisis of 1994-95, Argentina depleted about 20 percent of its international reserves to defend its currency board adopted in 1991. Even though the speculative attacks were massive at that time, EMP indices using precision weights do not show the speculative attack due to the almost zero weight in reserve changes. During the Asian crisis, Hong Kong hiked its interest rate to fight against strong speculative pressure. EMP indices with precision weights miss the unsuccessful speculative attack in the exchange market since exchange rate changes in Hong Kong have gained almost the entire weight through its currency board regime.

Precision weights are particularly inappropriate in constructing the EMP index under a pure fixed rate system or a clean float system. Under a fixed rate system the zero volatility of exchange rates would make the weight assigned to exchange rate changes infinitely large, while the weight assigned to reserve changes would be close to zero. In a country committed to maintaining its fixed rate regime the huge reserve loss due to fighting back speculative attacks would not have any impact on the EMP index at all. Therefore, the EMP index cannot pick up the market pressure from unsuccessful attacks. Under a free float system, an EMP index with precision weights would assign entire weight to the changes in international reserves due to its zero volatility. Thus, the speculative pressure absorbed by the exchange rate changes would not be captured by the EMP index.

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<sup>7</sup> See Nitithanprapas and Willett (2000) for a discussion of the Argentine case and Angkinand et al. (2006) for a discussion of the Hong Kong experience.

## 4.2 The EMP Index under a Pure Float Exchange Rate Regime

This subsection demonstrates the appropriate combination of the different components in the EMP index under a pure float exchange rate system. Under such a regime, the monetary authority abstains from intervening in the exchange market. This in turn leaves the reserves unchanged.<sup>8</sup> Excluding reserve changes, the original three-component EMP index is reduced to a new two-component EMP index. Equation (4) should be rewritten as follows:

$$m_t^s = m_{t-1}^s + \Delta d_t. \quad (19)$$

Thus, equations (1), (2), (3) and (19) constitute a new system of money market equilibrium without changes in reserves. Solving this system will shed light on the exchange rate elasticity of interest rates.

$$\Delta e_t = \gamma \Delta i_t + Y_t. \quad (20)$$

Therefore, the new EMP index is defined as follows:

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<sup>8</sup> Some reserve changes might be due to the interest earnings from the reserves investment or valuation effects due to changes in currency values. In undertaking empirical work, one should try to filter out the part of reserves changes which is not due to exchange market intervention.

$$EMP_t = \Delta e_t + \gamma \Delta i_t . \quad (21)$$

This equation reveals the true definition of the EMP index under a free float system. Under a free float system, the precision weights scheme would give entire weight to reserve changes and would ignore the changes in exchange rates and interest rates. But equation (21) tells us that the EMP index should comprise of only the changes of exchange rates and interest rates and ignore the unchanged reserves.

## 5. Concluding Remarks

While it is legitimate to use the precision weights scheme for market-determined variables in constructing composite variables, it is conceptually inappropriate to apply it to constructing the exchange market pressure (EMP) index. For instance, the reluctance to float exchange rates (i.e. “fear of floating”) leads to a much smaller variability in exchange rates vis-à-vis reserves. Therefore, the different volatilities in exchange rates and reserves could reflect largely the authority’s policy response function in relation to the speculative attacks. In particular, the greater volatility in reserves should be reflected in the EMP index. Therefore it would be inappropriate to discount the reserves changes too heavily in constructing the EMP index. However, the precision weights scheme imposes zero weight to reserve changes in a pure-fixed exchange rate regime and to exchange rate changes in a free float regime. This will lead to a downward bias for coding unsuccessful attacks such as Argentina in 1995 and Hong Kong in 1998. More

generally, precision weights in EMP indices have no clear economic interpretation since they are a combination of market generated volatilities and policy reaction functions. While such calculation gives very precise members, this imprecision of precision is largely spurious.

Under the assumption of money market equilibrium we derived the percentage changes of exchange rates in response to a one percentage changes of reserves and interest rates. These two elasticities reflect how much the exchange rate would have changed if there were no exchange market intervention or domestic interest rate hikes. In addition, we showed under what conditions equal weights scheme would be derived from our model.

Of course the model we used is not the only potentially relevant one; there is good reason to believe that the elasticities of international capital flows may vary substantially during crises. We would argue that the best case for using equal weights in the construction of EMP and crisis indices is not that these are clearly the theoretically correct weights, but rather that they be involved from the principle of equal ignorance and more honestly reflect our uncertainty about the correct weights. The use of ratios of variances gives an impression of precision that is unwarranted.

Given the low probability that we will be able to obtain good estimates of the relevant elasticities for large samples of countries anytime soon, we believe that it is extremely important for crisis researchers to investigate the sensitivity of their empirical results to alternative sets of weights.

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