Jurnal Ekonomi Pembangunan
Vol. 8, No. 1, Juni 2007, hal. 15 - 27

EXCHANGE RATE ECONOMICS AND MACROECONOMIC FUNDAMENTALS

Argamaya

Faculty of Economics, Universitas Trisakti, Jakarta
E-mail: rgmy2007@yahoo.co.id

ABSTRACT

Financial crises have a long history. Recently, several international crises emerged: the Mexican and Argentina currency and debt crisis of 1973–1982 and 1978–1981 respectively, the exchange rate crises following the abandonment of the European Exchange Rate Mechanism in 1992, the Tequila Effect resulting from the Mexican peso devaluation in 1992, the Asian Flu of 1997 resulting after Thailand's devaluation and the Russian Cold which arose from the collapse of the rubble in 1998. These episodes of international financial turmoil attracted worldwide attention; causes, impact and policy implications have been studied extensively.

Keywords: *Financial Crises, Exchange rate, and Exchange rate regimes*

INTRODUCTION

Financial crises have a long history. Recently, several international crises emerged: the Mexican and Argentina currency and debt crisis of 1973–1982 and 1978– 1981 respectively, the exchange rate crises following the abandonment of the European Exchange Rate Mechanism in 1992, the Tequila Effect resulting from the Mexican peso devaluation in 1992, the Asian Flu of 1997 resulting after Thailand's devaluation and the Russian Cold which arose from the collapse of the rubble in 1998. These episodes of international financial turmoil attracted worldwide attention; causes, impact and policy implications have been studied extensively.

Both theoretical and empirical research has been put forward to understand the causes of financial crises. Some theoretical studies focus on fundamentals while others move to non-fundamentals stories, such as self-fulfilling expectations and financial panics. On the empirical side, statistical and econometric models have been developed to test the relationship between crisis events and (non) fundamental factors. For instance, early warning systems are designed to prevent and manage crises with macroeconomic fundamentals as explanatory variables.[1] Other models test contagion channels and elements of financial panic.[2]

---

1 Interested readers are referred to Kaminsky, Lizondo, and Reinhart (1998) for papers on currency crises prior to the East Asian crisis, and Bustelo (2000) and Burkart and Coudert (2002) on the East Asian crisis; Gonzalez-Hermosillo (1996) and Dermirg¨u,c-Kunt and Detragiache (1997) on banking crises; and Marchesi (2003)'s survey on debt crisis.

2 See Rigobon (2002) and Dungey et al. (2003) for an overview.

The purpose of this paper is to provide some perspectives on fundamental-based theoretical framework on the onset of the currency crisis and how it related to measure currency crisis empirically.[3] The paper is structured as follows. Section 2 presents the model of speculative attack. Based on model under fixed and floating exchange rate regimes, the concept and timing of speculative attacks will be explored. Section 3 discuses the model of exchange market pressure which introduce the notion of (un)successful speculative attack. Furthermore, the measurement of currency crises will be reviewed. Section 4 concludes.

THEORETICAL FRAMEWORK

Theory of Currency Crises

1. The Model

The model of fundamental-based currency crisis is pioneered by Salant and Henderson (1978) and Krugman (1979).[4] We slightly modify and simplify the model by first introducing the exchange rate model under flexible and fixed regimes. The model begins by assuming that the world economy consists of one of a small open countries and a large foreign partner. Equilibrium in the domestic money market is assumed where demand of real money balance equals money supply, *i.e.* $m_t^d = m_t$.

$$\frac{M_t^d}{P_t} = L(i_{t+1}, Y_t)$$

$$m_t - p_t = \lambda t_{t+1} + \theta y_t \qquad .....(1)$$

where i the nominal interest rate; y real output, M^d nominal money demand, and *P* price level. All variables in lowercase denote logarithm terms.

The domestic money supply (M_t) is backed by two central bank assets composed of international reserves (D_t) and domestic credit (C_t) as in Equation (2) in log-linearized form. Then, money market equilibrium can be rewritten in Equation (3).

$$m_t = \alpha d_t + (1-\alpha)c_t \qquad .....(2)$$

$$\text{Where } \alpha = \frac{D_t}{M_t} \text{ and } (1-\alpha) = \frac{c_t}{m_t}$$

$$\alpha d_t + (1-\alpha)c_t - p_t = -\lambda i_{t+1} + \theta y_t \qquad .....(3)$$

The domestic interest rate and price level are subject to international arbitrage condition. Thus, it is assumed that there is free trade so that PPP (purchasing power parity) holds (Equation 4). The markets are efficient, therefore free capital mobility should assure that the return on capital assets equalized between countries (Equation 5).

$$\frac{P_t}{P_t^f} = \varepsilon_t$$

$$p_t = p_t^f + \varepsilon_t \qquad ......(4)$$

$$\frac{1+R_{t+1}}{1+R_{t+1}^f} = E_t\left(\frac{\varepsilon_{t+1}}{\varepsilon_t}\right)$$

$$i_{t+1} - i_{t+1}^f = E_t e_{t+1} - e_t \qquad .....(5)$$

---

3 Lestano and Jacobs (2002) provides a comprehensive overview on dating financial crises.

4 This model has been extended by its generation, among others, Flood and Garber (1984), Connolly and Taylor (1984), Krugman and Rotemberg (1992) and Flood, Garber, and Kramer (1996).

where P domestic price level; P^f foreign price level; ε nominal exchange rate; i domestic interest rates and i^f foreign interest rates. By substituting (4) and 5) into (3), we get

$$e_t = \frac{1}{1+\lambda}(\alpha d_t + (1-\alpha)c_t - p_t^f + \lambda i_{t+1}^f - \theta y_t) + \frac{\lambda}{1+\lambda}E_t e_{t+1} \quad .....(6)$$

Equation (6) shows that the current period of exchange rates, (e_t), is determined by fundamental macroeconomic variables, *i.e.*, money balance, m_t, price level, p_t, and real output, y_t, and the future exchange rate expectations. This equation is solved by summing the exchange rates expectations and the values of the fundamental variables in all the previous periods, which determine the exchange rates in the current periods.

$$e_t = \frac{1}{1+\lambda}\sum_{s=t}^{\infty}\left(\frac{\lambda}{1+\lambda}\right)^{s-t}(\alpha d_s + (1-\alpha)c_s - p_s^f + \lambda i_s^f - \theta y_s) + \lim_{T\to\infty}\left(\frac{\lambda}{1+\lambda}\right)^T E_t e_{t+T} \quad ..(7)$$

It is assumed that there are no speculative bubbles in exchange rate. Indeed, the last term of right hand side of Equation (7) will be zero unless the exchange rate changes at an ever increasing proportional rate. Then, we can express the exchange rate model as:

$$e_t = \frac{1}{1+\lambda}\sum_{s=t}^{\infty}\left(\frac{\lambda}{1+\lambda}\right)^{s-t}(\alpha d_s + (1-\alpha)c_s - p_s^f + \lambda i_{s+1}^f - \theta y_s) \quad ......(8)$$

This model features a completely floating exchange rates regime and free capital mobility. Theoretically, there should not be an attack on the currency, since exchange rate changes reflect changes in fundamental macroeconomic variables. An increase in the money stock will lead to a higher exchange rate. In other words, an increase in the money stock leads to depreciation as a higher rate implies that it takes more units of the home currency to buy one unit of the foreign currency. A lower money stock and higher output will imply a stronger exchange rate. However, if foreign interest rates rise, the currency will depreciate.

In the case of the exchange rate is set to be fixed at $e_t = \bar{e}$, it follows that $E_t e_{t+1} = e_t$ and thus uncovered interest parity does not hold, *i.e.*, $i_{t+1} = i_{t+1}^f$. We can rearrange equation (3) as

$$\alpha d_t + (1-\alpha)\bar{c}_t - p_t^f - \bar{e} = -\lambda i_{t+1}^f + \theta y_t \quad ...(9)$$

The foreign price level, foreign-currency interest rate, real income, and fixed exchange rate are exogenous, while the money supply is treated as endogenous in this case. Hence, the movement in y_t, p_t, and i_{t+1}^f can neglected, the Equation (9) can be written as Equation (10) or equivalently equation (11).

$$\alpha d_t + (1-\alpha)c_t = \bar{e} + p^f - \lambda i^f + \theta y \quad ......(10)$$

$$\alpha d_t + (1-\alpha)c_t = \bar{e} + \delta \quad .....(11)$$

The growth rate of d_t and c_t are $\dot{d}_t = \omega$ and $\dot{c}_t = \phi$, respectively, then equation (11) becomes

$$\omega = -\left(\frac{1-\alpha}{\alpha}\right)\phi \qquad \text{......(12)}$$

If d_t grows at rate ω, then c_t falls at the rate depended on $\frac{1-\alpha}{\alpha}$. An increase in the central bank domestic assets must be offset by a decrease in its international assets. The money stock must likewise be fixed, when exchange rate is fixed and expected to stay that way. The central bank must adjust money supply accordingly to support a fixed exchange rate. In maintaining the exchange rate at a fixed level, a central bank must reduce international reserves up to its complete exhaustion level, $c_t = 0$. At this point the previously established exchange rate parity cannot be defended and eventually devaluation or the abandonment of exchange rate peg takes place.

2. Speculative Attacks

The source of disequilibrium in fundamental-based currency crisis models comes from a budget deficit that monetizes through the growth of domestic credit (ω). At exhausted level of foreign reserves $(c_t = 0)$ or even prior that matters, speculators will precisely estimate the developments of the fundamental macroeconomic variables (growth rate of money supply) and predict the forthcoming course of events and begin selling domestic currency and buying foreign exchange to prevent losses when devaluation takes place. In this case, the speculator coherent will cause speculative attack on the domestic currency and a more rapid depletion of international reserves, then leading to an earlier devaluation or the abandonment of exchange rate peg.

In this model of currency crisis, it is possible to determine the time when a speculative attack occur by introducing the concept of shadow exchange rate denoted by $\tilde{e}$. This shadow exchange rate is defined as the market exchange rate that would be obtain when the international are exhausted, or the market rate that the monetary authority can no longer defend exchange rate. By assuming that the movement in y_t, p_t, and i^f_{t+1} are neglected and the actual and expected rate of exchange rate change depends on domestic growth rate $(E_t e_{t+1} - e_t = \phi)$, then Equation (3) can be rewritten once more to give the condition at $e_t = \tilde{e}$:

$$\alpha d_t + (1-\alpha)c_t = \tilde{e} - \lambda\phi + p^f - \lambda i^f + \theta y \quad \text{..(13)}$$

$$\alpha d_t + (1-\alpha)c_t = \tilde{e} - \lambda\phi + \delta \qquad \text{...(14)}$$

At the level that international reserves are depleted, therefore $c_t = 0$, then the shadow exchange rate prevails at

$$\tilde{e} = \alpha d_t + \lambda\phi - \delta \qquad \text{......(15)}$$

Figure 1 illustrates Equation (15). At point where the fixed exchange rate ($\bar{e}$) intersects with the shadow exchange rate ($\tilde{e}$), the speculator will instigate an attack. In this case, the losses and profits from intertemporal currency arbitrage are equal. The speculator will gain profits in case of attack due to the resulting depreciation of exchange rate when d_t is greater than d^A. Conversely, if $d_t < d^A$ then there will be capital losses for speculators as an attack in this area will appreciate the currency.

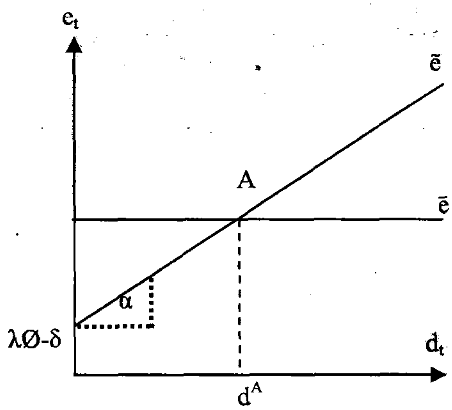

Figure 1. Timing of Speculative Attacks

To find out the exact timing of currency crisis, let assume the growth path of domestic credit is

$$d_t = d_0 + \omega t \qquad \text{...... (16)}$$

Since the actual exchange rate equals to shadow one at the moment of a speculative attack, we can write

$$\bar{e} = \alpha(d_0 + \omega t) + \lambda\phi - \delta \qquad \text{......(17)}$$

It follows that the time of attack, *T*, is

$$T = \frac{\bar{e} - \alpha d_0 - \lambda\phi + \delta}{\alpha\omega} \qquad \text{......(18)}$$

Equation (18) shows that the time of a speculative attack depends on the developments in fundamental macroeconomic variables, *i.e.*, budget deficit growth rates.

Measurement of Currency Crises

1. The Model

The monetary model of exchange market pressure is first proposed by Girton and Roper (1977). The model clarified that a change in both international reserve and price of foreign exchange could affect the disequilibrium of foreign exchange market or the pressure on external position of a country. Many empirical studies then tried to apply the model to a country or group of countries, for instance, Weymark (1997) for Canada, Oskooee and Bernstein (1999) for the G-7, and Pentecost *et al.* (2001) for the EU.

The model presented in this section is a slightly modified version of the exchange market pressure model of Girton and Roper (1977).[5] Unlike Girton and Roper, we include the interest differential between the home country and the reference country since the pressure on exchange market is due partly and frequently to interest rates shocks. We take a general money demand model. Different specifications have been used by others, for example, Girton and Roper (1977) assume an exponential money demand function and Pentecost et al.(2001) and Oskooee and Bernstein (1999) adopt log-linear models.

Consider a home economy in which money demand is determined by the level of real income (Y), price level (P), wealth of non-bank private sector (W), and interest rates. Following Pentecost et al. (2001) and Fase and Winder (1993), there are three kinds of interest rates, i.e. short-term rate for money balances (Φ), and the return on

[5] See Lestano and Jacobs (2002) for further details

domestic and foreign long-term assets, respectively i and i^f. The later interest rates relate inversely with money demand. The general model of demand for nominal money balances is given by

$$M_t^d = f\left(P_t, Y_t, W_t, \Phi_t, i_t, i_t^f\right) \qquad \ldots\ldots(19)$$

The supply of base money (M^s) is simply a fraction of net foreign assets (F) and domestic credit (D). The stock of foreign assets is the sum of the flows of international reserves and consists of which divided into primary assets (R) and foreign exchange (Rf). The supply of nominal money and the specification of foreign assets stock are outlined by Equations (20) and (21).

$$M_t^s = m_t\left(F_t + D_t\right) \qquad \ldots\ldots(20)$$

$$F_t = \int_{-\infty}^{t} E_t R_t \, dt + \int_{-\infty}^{t} E_t^f R_t^f \, dt \qquad \ldots\ldots(21)$$

where m_t is the money multiplier [6] and E and E^f denote the currency values of R and R^f respectively. The dots over the variable denote time derivative of that variable.

The equilibrium in the money market is given by

$$M_t^s = M_t^d \qquad \ldots\ldots(22)$$

Taking time differentials of equation (19) and substituting equation (21) into the first time differentials of equation (20), the money market equilibrium becomes

$$a_t + r_t + d_t = \varepsilon_p p_t + \varepsilon_y y_t + \varepsilon_w w_t + \varepsilon_\phi \phi_t + \varepsilon_i \rho_t + \varepsilon_i^f \rho_t^f \qquad \ldots\ldots(23)$$

where

$$a_t = \frac{\dot{m}_t}{m_t},\ r = \frac{E_t \dot{R}_t}{F_t + D_t} + \frac{E_t^f \dot{R}_t^f}{F_t + D_t},$$

$$d_t = \frac{\dot{D}_t}{F_t + D_t},\ y_t = \frac{\dot{Y}_t}{Y_t},\ p_t = \frac{\dot{P}_t}{P_t},$$

$$w_t = \frac{\dot{W}_t}{W},\ \phi_t = \frac{\dot{\phi}_t}{\phi_t}, \text{and}$$

$$\rho_t = \frac{\dot{i}_t}{i_t},\ \rho_t^f = \frac{\dot{i}_t^f}{i_t^f}$$ and the $\varepsilon_p, \varepsilon_y, \varepsilon_w, \varepsilon_\phi, \varepsilon_i$ and ε_i^f are the money demand elasticity with respect to price level, income, private non-bank wealth, and returns on money balances, domestic and foreign assets.

Now consider a foreign country that has the same model specification with a home money market equilibrium, thus we can write the Equation (23) where the elasticity of money demand with respect to domestic (local) and foreign assets are respectively denoted by ε_i and ε_i^f. Following Girton and Roper (1977) and Pentecost et al. (2001), the purchasing power parity (PPP) condition in (25) is used to link the money market between home and foreign. This condition says that deviations of rates of change of nominal exchange rate (e_t) from the inflation differential is determined by the amount of rates of change of real exchange rate (θ_t).

$$a_t^f + r_t^f + d_t^f = \varepsilon_p p_t^f + \varepsilon_y y_t^f + \varepsilon_\phi \phi_t^f + \varepsilon_i \rho_t^f + \varepsilon_i^f \rho_t \qquad \ldots\ldots(24)$$

$$e_t = p_t - p_t^f + \theta_t \qquad \ldots\ldots(25)$$

[6] Girton and Roper (1977) and Pentecost *et al.* (2001) assume a constant money multiplier equal to unity.

where

$$e_t = \frac{E_t}{E_t},\ \theta_t = \frac{Q_t}{Q_t},$$

E_t = nominal exchange rate, and

Qt = real exchange rate

Subtracting (23) from (24) and using equation (25), we obtain:

$$\left(a_t - a_t^f\right) + \left(d_t - d_t^f\right) - \varepsilon_y\left(y_t - y_t^f\right) - \left(\varepsilon_i - \varepsilon_i^f\right)\left(\rho_t - \rho_t^f\right) + \varepsilon_p\theta_t = \varepsilon_p e_t + \varepsilon_\theta\left(\phi_t - \phi_t^f\right) - \left(r_t - r_t^f\right) \qquad \ldots\ldots(26)$$

The right-hand side of Equation (26) present exchange market pressure. It is clearly interpreted that domestic and foreign growth of output and credit, interest rate differential, money multiplier differential and real exchange rate (domestic competitive-ness) are triggering determinants of a devaluation and a speculative attacks. The successful speculative attack picks the exchange rate pressure up, which is indicated by exchange rate depreciation. Authorities can also interfere the foreign exchange market for the purpose to defend currency from attacks. The intervention involves either losing international reserves or raising domestic interest rates.

2. Currency Crises Dating

a. Currency crises dating, method ERW

Eichengreen, Rose, and Wyplosz (1995, 1996) made an important early effort to develop a method to measure currency pressure and to date currency crises. Their definition of exchange rate pressure is inspired by the monetary model of Girton and Roper (1977): a speculative attack exists only in the form of extreme pressure in the foreign exchange market, which usually results in a devaluation (or revaluation), or a change in the exchange rate system, i.e. to float, fix or widen the band of the exchange rate. However, speculative attacks on exchange rates can also be unsuccessful. When facing pressure on its currency, the authorities have the option to raise interest rates or to run down international reserves. Hence, speculative pressure is measured by an index that is a weighted average of normalized changes in the exchange rate, the ratio of gross international reserves to M1, and the nominal interest rates. All variables are relative to a reference country, for which a country is selected with a strong currency that serves as an anchor to other countries. The index of exchange rate pressure is defined as follows:

$$EMPI_{i,t} = \frac{1}{\sigma_e}\frac{\Delta e_{i,t}}{e_{i,t}} - \frac{1}{\sigma_r}\left(\frac{\Delta rm_{i,t}}{rm_{i,t}} - \frac{\Delta rm_{US,t}}{rm_{US,t}}\right) + \frac{1}{\sigma_i}\Delta\left(i_{i,t} - i_{US,t}\right) \qquad \ldots\ldots(27)$$

where $EMPI_{i,t}$ is the exchange rate market pressure index for country *i* in period *t*; $e_{i,t}$ the units of country *i's* currency per US dollars in period t; $rm_{i,t}$ the ratio of gross foreign reserves to M1 for country *i* in period *t*, $i_{i,t}$ the nominal interest rates for country *i* in period *t*; $i_{US,t}$ the nominal interest rates for the reference country (US) in period *t*; σ_e the standard deviation of the relative change in the exchange rate $(\Delta e_{i,t}/e_{i,t})$, σ_r is the standard deviation of the difference between the relative changes in the ratio of foreign reserves and money (M1) in country *i* and the reference country (US) $((\Delta r_{i,t}/r_{i,t})$ –

($\Delta rm_{US,t}/rm_{US,t}$)), and σ_i the standard deviation of the nominal interest rate differential $\Delta(i_{i,t} - i_{US,t})$.

This measure is intuitively appealing. In case of speculative pressure, the index captures changes in the domestic exchange rate if the attack is successful and changes in international reserves or nominal interest rates if the speculative attack does not lead to a devaluation. A period of speculative attack is identified when the index exceeds some upper bound:

$$\text{Crises} = \begin{cases} 1 \text{ if } \text{EMPI}_{i,t} > \beta\sigma_{\text{EMPI}} + \mu_{\text{EMPI}} \\ 0 \text{ otherwise} \end{cases}$$

where σ_{EMPI} equals the sample standard deviation of EMPI and μ_{EMPI} is the sample mean of *EMPI*. Eichengreen, Rose, and Wyplosz (1995) arbitrarily set a threshold of $\beta = 2$, i.e. two standard deviations above the mean, $\beta = 1.5$ is chosen in Eichengreen, Rose, and Wyplosz (1996).

b. Currency crises dating, method KLR

Kaminsky, Lizondo and Reinhart (1998) and Kaminsky and Reinhart (1999, 2000) modify the exchange market pressure index of Equation (27) by dropping the interest rate differentials since interest rates were controlled by central banks in their sample, the 1970s and 1980s, and links to the reference country. In addition, foreign reserves are no longer scaled by money supply (M1). Finally, the right-hand-side is multiplied by the standard deviation of the relative change in the exchange rate:

$$\text{EMPI}_{i,t} = \frac{\Delta e_{i,t}}{e_{i,t}} - \frac{\sigma_e}{\sigma_r}\frac{\Delta r_{i,t}}{r_{i,t}} \quad \ldots\ldots(28)$$

where $r_{i,t}$ gross foreign reserves of country i in period t, σ_r the standard deviation of the relative change in the reserves ($\Delta r_{i,t}/r_{i,t}$).

To avoid the problem that currency crises are associated with high inflation, the sample is split into periods with hyper-inflation and low inflation; separate indexes are constructed for each subsample. The definition of a currency crisis is the same as in *ERW*, but the threshold to define a currency crisis is set to three standard deviation above the mean.

c. Currency crises dating, method FR

Frankel and Rose (1996) exclude unsuccessful speculative attacks from the exchange rate pressure concept. In their opinion international reserves are too rough a proxy to measure policy actions in defense of the currency. In addition, they argue that raising interest rates and exhausting international reserves is not standard practice to deal with speculative attack in most of the developing countries.

The method of Frankel and Rose (1996) uses only nominal exchange rate variables and defines a currency crash as a nominal depreciation of the currency of at least 25 percent which is accompanied by an increase in the rate of depreciation of at least 10 percent. The latter cut-off point is used to avoid registering periods with high inflation, which are usually followed by high depreciation. So, a currency crash is defined as

$$\text{Crises} = \begin{cases} 1 \text{ if } \%\Delta e_{i,t} > 25\% \text{ and } \%\Delta e_{i,t} > 10\% + \%\Delta e_{i,t-1} \\ 0 \text{ otherwise} \end{cases} \quad \ldots\ldots(29)$$

d. Currency Crises Dating, Method Z

Zhang (2001) criticized ERW's exchange market pressure by pointing at two problems. First, changes in international reserves and interest rates may cancel against each other if the speculative attack is successful. For example, a positive change in the exchange rate (in anticipation of a devaluation) may trigger a fall in the interest rate and an increase in international reserves. Secondly, movements in international reserves and exchange rate can be volatile in some periods and relatively tranquil in other periods. Thus, an event that results in high volatility dominates the whole sample.

To tackle both problems, Zhang suggested decomposing the exchange rate market pressure index of ERW into its components and to use time-varying thresholds for each component. Zhang (2001) excludes interest rate variables and also drops the link to the reference country.

$$\text{Crises} = \begin{cases} 1 \text{ if} \begin{cases} \Delta e_{i,t} / e_{i,t} > \beta_1 \sigma_{e,t} + \mu_{e,t} \quad \text{or} \\ \Delta r_{i,t} / r_{i,t} < \beta_2 \sigma_{r,t} + \mu_{r,t} \end{cases} \\ 0 \text{ otherwise} \end{cases} \quad \ldots(30)$$

where the standard deviations $\sigma_{e,t}$ and $\sigma_{r,t}$ are calculated for the sample (t − 36, t − 1). Zhang arbitrarily set the thresholds to $\beta_1 = 3$ and $\beta_2 = -3$.

e. Currency Crises Dating: Event Studies and Extreme Value

Many studies on contagious currency crises use event-based definitions. Currency crises are identified qualitatively, by simply plotting the exchange rate series and picking up the high volatility, or by relying on the records of well-documented event chronologies, (abandonment of exchange rate peg, devaluations, suspension of convertibility, *etc.*) from newspapers and journals, academic reviews and reports of international organizations. Granger, Huang, and Yang (2000) and Ito and Hashimoto (2002) use extreme jumps in exchange rates. Examples for news-based currency crisis dating are Glick and Rose (1999), Baig and Goldfajn (1999), Nagayasu (2001), and Dungey and Martin (2002).

The dating schemes discussed above are based in an index of exchange market pressure *EMPI*. The tails of the distribution of *EMPI* are interpreted as results of (un)successful speculative attack against the currency of the country and have direct links to currency crisis dates. A currency crisis is signalled when $EMPI_{i,t}$ is more than a threshold above the mean. The threshold is in terms of a number of standard deviations and based on the arbitrary assumption that the index follows a well-behaved normal distribution $\text{EMPI} \sim N(0, \sigma^2_{\text{EMPI}})$ However, the normality condition need not necessarily hold in this case due to '*fat tails*' (*leptokurtic*), skewness, or infinite second moments. So, Pozo and Amuedo-Dorantes (2003) suggest to use extreme value theory which concentrates on the distribution of the tails.[7] Here, extreme values of *EMPI* determine the crisis dates, and there is no need to set an arbitrary threshold value for *EMPI*.

The distribution of *EMPI* can be characterized by the tail parameter (α). Pozo and Amuedo-Dorantes (2003) estimate the parameter (α) of the fat tail of the *EMPI*

[7] Koedijk, Schafgans and De Vries (1990) applied extreme value theory in the study of exchange rate returns.

distribution by using the Hill estimator (Hill, 1975).[8] The Hill estimator assumes stationary and serially uncorrelated series. The series *EMPI* = $EMPI_1, \ldots, EMPI_t$ is ordered according to ascending size in n categories $EMPI_{(1)} \leq \ldots \leq EMPI_{(t)}$. The Hill estimator of α is defined as

$$\hat{\gamma} = \frac{1}{\hat{\alpha}} = \frac{1}{m}\left[\sum_{t=1}^{m} \log \mathrm{EMPI}_{n+1,t} - \log \mathrm{EMPI}_{n-m}\right]$$

where m is the largest number that is used in the calculation of $\hat{\gamma}$, a consistent estimator of γ which is distributed as $m^{1/2}\left(\hat{\gamma} - \gamma\right) \sim N\left(0, \gamma^2\right)$.

The estimator of $1/\alpha$ is computed for several values of m. The estimation procedure requires $m(n) \to \infty$, but for a finite sample it is not known to select m optimally. There are three procedures to choose the optimal value of m for finite sample. First procedure is to use Hill's plot. The values of $1/\alpha$ is calculated for different m, then plot the two parameters. The m-value is selected in the region over which $1/\alpha$ is stable. The other two procedures are recursive least squares and Monte Carlo experiment. Pozo and Amuedo-Dorantes (2003) suggest recursive least squares: $1/\hat{\alpha}$ is regressed on a constant and trend. Observation are added successively which yields a series of fitted values for $1/\hat{\alpha}$. The stable estimation of $1/\hat{\alpha}$ is obtained if in certain value of m the plot of recursive residuals outside the standard error bands. The efficiency-bias trade-off[9] 7 occurs in the last two methods. A Monte Carlo experiment proposed by Koedijk, Schafgans and De Vries (1990) and Longin and Solnik (2001) can be employed to find optimal m without bias and inefficiency. The minimum MSE criterion of $\hat{\gamma}$ is used to select m for given n and degrees of freedom.

CONCLUSION

We slightly modify two theoretical models of currency crises in which related with macroeconomic fundamentals. First model show the inconsistencies between fiscal, monetary and exchange rate policies and the role of speculative attacks in forcing the abandonment of a currency peg. In addition, the exact timing of speculative attacks is derived. Second model derive the fundamentals determinant of the exchange rate market pressure. Empirical studies on currency crises took this model to calculate *EMPI* and identify the tranquility and currency crisis episodes.

Experimentation with the methods for a panel of six Asian countries (Indonesia, Malaysia, Philippines, Singapore, South Korea and Thailand) covering the period January 1970–December 2002 revealed that differences in currency crises chronologies can indeed be large. The outcomes of ERW and KLR more or less correspond; the other

[8] An alternative is maximum likelihood (ML) proposed by Akgiray, Booth and Seifert (1988). However, Koedijk, Stork and De Vries (1992) argue that the Hill estimator is more efficient than ML estimator.

[9] If one use an m is too low or using too few tail observations, an estimate of α will be obtained with too large a variance (inefficient). Contrary, the α estimation will be biased due to including observations that are not tail observations.

three, FR, Z, and extreme value, deviate (Lestano and Jacobs, 2002). Nevertheless, there is scope for effective policy design since significant indicators for currency crises could be identified.

REFERENCES

Akgiray, V., G. G. Booth and B. Seifert (1988), "Distribution Properties of Latin American Black Market Exchange rates", *Journal of International Money and Finance*, 7(1), 37–48.

Baig, T. and I. Goldfajn (1999), "Financial Market Contagion in the Asian crisis", *IMF Staff Papers* 46/2, International Monetary Fund, Washington, D.C.

Burkart, O. and V. Coudert (2002), "Leading Indicators of Currency Crises for Emerging Countries", *Emerging Markets Review*, 3(2), 107–133.

Bustelo, P. (2000), "Novelties of Financial Crises in the 1990s and the Search for New Indicators", *Emerging Markets Review*, 1(3), 229–251.

Connolly, M.B. and D. Taylor (1984), "The Exact Timing of the Collapse of an Exchange Rate Regime and its Impact on the Relative Price of Traded Goods", *Journal of Money, Credit and Banking*, 16(2), 194–207.

Dermirg¨u¸c-Kunt, A. and E. Detragiache (1997), "The Determinants of Banking Crises in Developing and Developed Countries", *IMF Working Paper* 106, International Monetary Fund, Washington, D.C.

Dungey, M., R. Fry, B. Gonzalez-Hermosillo, and V.L. Martin (2003), "Empirical Modelling of Contagion: a Review of Methodologies", *Working Papers 8*, Cambridge Endowment for Research in Finance, Cambridge.

Dungey, M. and V.L. Martin (2002), "Measuring contagion in the East Asian Currency Crisis", *Mimeo*, The Australian National University, Canberra, Australia.

Eichengreen, B., A.K. Rose, and C. Wyplosz (1995), "Exchange rate mayhem: the Antecedents and Aftermath of Speculative Attacks", *Economic Policy*, 21, 251–312.

Eichengreen, B., A.K. Rose, and C. Wyplosz (1996), "Contagious Currency Crises", *Scandinavian Journal of Economics*, 98(4), 463–484.

Fase, M.M.G and C. Winder (1993), "the Demand for Money in the Netherlands and the other EC Countries", *De Economist*, 141(14), 471–496.

Flood, R.P., P.M. Garber and C. Kramer (1996), "Collapsing Exchange Rate Regimes: Another Linear Example", *Journal of International Economics*, 41(34), 223–234.

Flood, R.P. and P.M. Garber (1984), "Collapsing Exchange Rate Regimes: some Linear Examples", *Journal of International Economics*, 17, 1–13.

Frankel, J.A. and A.K. Rose, "Currency Crashes in Emerging Markets: an Empirical Treatment", *Journal of International Economics*, 41(3-4), 351–366.

Girton, L. and D. Roper (1977), "A Monetary Model of Exchange Market Pressure Applied to the Postwar Canadian Experience", *American Economic Review*, 67(4), 537–548.

Glick, R. and A.K. Rose (1999), "Contagion and Trade: Why are Currency Crises regional?", *Journal of International Money and Finance,* 18(4), 603–617.

Gonzalez-Hermosillo, B. (1996), "Banking Sector Fragility and Systemic Sources of Fragility", *IMF Working Paper* 12, International Monetary Fund, Washington, D.C.

Granger, C.W.J., B.W. Huang and C.W. Yang (2000), "A Bivariate Causality between Stock Prices and Exchange Rates: Evidence from Recent Asian flu", Quarterly *Review of Economics and* Finance, 40(3), 337–354.

Hill, B.M. (1975), "A Simple General Approach to Inference about the Tail of a Distribution", *Annuals of Statistics,* 3(5), 1163–1174.

Ito, T. and Y. Hashimoto (2002), "High Frequency Contagion of Currency Crises in Asia", *NBER Working Paper* 9376, National Bureau of Economic Research, Cambridge, MA.

Kaminsky, G.L., S. Lizondo, and C.M. Reinhart (1998), "Leading Indicators of Currency Crisis", *IMF Staff Papers* 45/1, International Monetary Fund, Washington, D.C.

Kaminsky, G.L. and C.M. Reinhart (1999), "The Twin Crises: the Causes of Banking and Balance-of-Payments Problems", *American Economic Review,* 89(3), 473–500.

Kaminsky, G.L. and C.M. Reinhart (2000), "On Crises, Contagion, and Confusion", *Journal of International Economics,* 51(1), 145–168.

Koedijk, K.G., M.M.A. Schafgans and C.G. de Vries (1990), "The Tail Index of Exchange Rate Returns", *Journal of International Economics*, 29(1-2), 93–108.

Koedijk, K.G., P.A. Stork and C.G. de Vries (1992), "Differences between Foreign Exchange Rate Regimes: the View from the Tails", *Journal of International Money and Finance,* 11(5), 462–473.

Krugman, P. (1979), "A Model of Balance-of-Payments Crises", *Journal of Money, Credit and Banking*, 11(3), 311–325.

Krugman, P. and J. Rotemberg (1992), "Speculative Attacks on *Target Zones*", in P. Krugman and M. Miller, editors, *Exchange Rate Target and Currency Bands,* Cambridge University Press, Cambridge, 117–132.

Lestano and J.P.A.M. Jacobs (2002), "Dating Asian Currency Crises 1970-2002: a Comparison of Method", *Mimeo*, Department of Economics, University of Groningen, The Netherlands.

Longin, F. and B. Solnik (2001), "Extreme Correlation of International Equity markets", *Journal of Finance,* 56(2), 649–676.

Marchesi, S. (2003), "Adoption of an IMF Programme and Debt Rescheduling", *Journal of Development Economics,* 70(2), 403–423.

Nagayasu, J. (2001), "Currency Crisis and Contagion: Evidence from Exchange Rates and Sectoral Stock Indices of the Philippines and Thailand", *Journal of Asian Economics*, 12(4), 529–546.

Oskooee, M.B. and D.J. Bernstein (1999), "Exchange Rate Market Pressure during the Current Managed Float", *Applied Economics Letters*, 6(9), 585–588.

Pentecost, E.J., A. van Poeck, and C. van Hooydonk (2001), "Measuring and Estimating Exchange Market Pressure in the EU", *Journal of International Money and Finance*, 20(3), 401–418.

Pozo, S. and C. Amuedo-Dorantes (2003), "Statistical Distributions and the Identification of Currency Crises", *Journal of International Money and Finance*, 22(4), 591–609.

Rigobon, R. (2002), *International Financial Contagion: Theory and Evidence in Evolution*, Monograph, Research Foundation of Association for Investment Management and Research, Virginia.

Salant, S.W. and D. W. Henderson (1978), "Market Anticipations of Government Policies and the Price of Gold", *Journal of Political Economy*, 86(4), 627–648.

Weymark, D.N. (1997), "Measuring the Degree of Market Exchange Intervention in A Small Open Economy", *Journal of International Money and Finance*, 16(1), 55–79.

Zhang, Z. (2001), "Speculative Attacks in the Asian Crisis", IMF Working Paper 189, International Monetary Fund, Washington, D.C.