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BOP Crises and External Shocks*

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Abstract

This is a theoretical study of BOP crises in emerging markets in East Asia and Latin America in the 1990s. These BOP crises tend to be preceded by the current account deterioration, the real exchange rate appreciation, and inflationary pressures. The paper develops a model of BOP crises preceded by these macroeconomic phenomena. The model shows that an external shock (a decrease in the world nominal interest rate) leads to this type of BOP crises.

1. Introduction

The balance of payments (BOP) crises in emerging markets in East Asia and Latin America in the 1990s share notable common features. These crises tend to be preceded by the current account deterioration and the real exchange rate appreciation. Sachs, Tornell, and Velasco (1996) mention that the current account deficit and the real exchange rate appreciation are significant elements of the crises in Latin American countries. Corsetti, Peseneti, and Roubini (1998) analyze the period leading to East Asian crises, and argue that large current account deficits and real exchange appreciations can have played important roles in the dynamics of the Asian currency and financial crisis. According to them,"*as a group, the countries that came under attack in 1997 appear to have been those with large current account deficits throughout the 1990s*" (emphases in the original, p.7). "Taking 1990 as the base year, we observe that by the spring of 1997 the real exchange rate had appreciated by 19% in **Malaysia**, 23% in the **Philippines**, 12% in **Thailand**, 8% in **Indonesia**, 18% in **Singapore**, and 30% in **Hong Kong**. In **Korea** and **Taiwan**, the currency *depreciated* in real terms (respectively by 14% and 10%). This suggests that *with the important exception of Korea, all the currencies that crushed in 1997 had experienced a real appreciation*"(emphases in the original, p.20). Radelet and Sachs (2000) also argue that a current account deficit and a real exchange appreciation are important factors behind the East Asian crises. In addition, inflationary pressures were observed in the emerging markets in Latin America and parts of Asia in the 1990s (Calvo, Leiderman, and Reinhart, 1994). In Latin America, the inflationary pressures were more evident than in East Asia.

What causes the BOP crises accompanied by the large current account deficit, the real exchange rate appreciation, and inflationary pressures in emerging markets? Radelet and

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Sachs (2000) state that the massive capital inflows into the emerging markets in East Asia during the 1990s are at the core of the crises. The period preceding BOP crises in Latin American countries is also characterized by large capital inflows (Calvo, Leiderman, and Reinhart, 1994). Frankel and Okongwu (1996) show that the capital inflow into emerging markets in Latin America and East Asia in the late 1980s and early 1990s can be attributed to the low interest rates prevailing in the United States. In addition, Fernández-Arias (1996), Dooley, Fernández-Arias, and Kletzer (1994), and Calvo, Leiderman, and Reinhart (1994) reach the similar conclusion that the external factor originated in the creditor countries is the dominant cause of the inflows into the debtor countries. According to these empirical studies, the low world interest rate seems to have been a major cause of the capital iflows leading to the crises accompanied by the current account deficit, the real exchange appreciation, and inflationary pressures.

These notable features of the BOP crises in emerging markets in East Asia and Latin America in the 1990s motivate this paper. The paper develops a model of BOP crises preceded by the current account deficit, the real exchange appreciation, and inflationary pressures. As the cause of the crises, we emphasize a decrease in the world nominal interest rate in this analysis. In other words, the paper develops a model of BOP crises triggered by an external factor to the developing countries. The model follows the so-called "classical" generation model of BOP crises represented by Krugman (1979) and Calvo (1987), which emphasize inconsistency in macroeconomic policies. Krugman (1979) shows that BOP crises arise from the unsustainable combination of the government's fiscal policy and its domestic credit policy. In Calvo (1987)'s model, the inflation stabilization policy that prevails mainly in Latin American countries causes the inconsistency between the fiscal policy and the domestic credit policy[1] . In contrast, in our model, a decrease in the world nominal interest rate leads to the inconsistency resulting in a BOP crisis. We also analyze how the size of this external shock affects the time of the crisis and its macroeconomic effects. It is shown that a larger external shock hastens the time of the crisis. In addition, as the size of the external shock becomes larger, the economy will experience a larger deficit in the current account, a greater appreciation of the real exchange rate, and a higher inflationary pressure.

The paper proceeds as follows. Section 2 presents the model. Section 3 analyzes the macroeconomic effects of a permanent decrease in the world nominal interest rate. Section 4 examines how the size of this external shock affects the time of a BOP crisis and the macroeconomic effects preceding the crisis. Section 5 summarizes the main results of our analysis.

2. The Model

2.1 Consumers

Consider a small open economy perfectly integrated with the rest of the world in goods and capital markets. The law of one price holds for the tradable good. Namely, we have $P_t = E_t P_t^*$, where E_t, P_t, and P_t^* denote the nominal exchange rate, the domestic price level of tradable goods, and the foreign price level of tradable goods at time t, respectively.

The representative household's instantaneous utility separately depends on consumption of tradables, c_t^T, and non-tradables (or home goods), c_t^N. Thus, the lifetime utility as of the time 0 can be written as

$$\int_0^\infty \{u(c_t^T) + z(c_t^N)\} e^{-\beta t}\, dt, \tag{1}$$

where the utility functions $u(\cdot)$ and $z(\cdot)$ are increasing, twice-continuously differentiable, and strictly concave. $\beta(>0)$ is the rate of time preference.

The individual has a constant endowment flow of tradable goods, y^T, and non-tradable goods, y^N. There are two assets available to consumers in this economy: domestic currency, M_t, and internationally traded asset holdings, B_t. Real money balances are denoted by $m_t(\equiv \frac{M_t}{P_t} = \frac{M_t}{E_t P_t^*})$. Real private foreign asset holdings are denoted by $b_t(\equiv \frac{B_t}{P_t^*})$. Financial wealth of consumers in terms of tradable goods is denoted by a_t:

$$a_t = m_t + b_t. \tag{2}$$

The individual's flow budget constraint is given by

$$\dot{a}_t = ra_t + y^T + \frac{y^N}{e_t} + \tau_t - c_t^T - \frac{c_t^N}{e_t} - i_t m_t - s_t. \tag{3}$$

r is the (constant) world real interest rate. τ_t is the government lump-sum transfer. i_t is the nominal interest rate. Then, the term $i_t m_t$ indicates an inflation tax. e_t denotes the real exchange rate, which is the relative price of tradable goods in terms of non-tradable goods, i.e., $e_t = \left(\frac{P_t}{P_t^N}\right) = \left(\frac{E_t P_t^*}{P_t^N}\right)$. P_t^N denotes the non-tradable goods price. Therefore, a reduction in e_t indicates an appreciation of the real exchange rate. Transactions costs (s_t), which are assumed to be increasing in consumption and decreasing in real money balances, are given by[2]

$$s_t = \left(c_t^T + \frac{c_t^N}{e_t}\right) v\left(\frac{m_t}{c_t^T + \frac{c_t^N}{e_t}}\right), \quad v'(\cdot) < 0,\ v''(\cdot) > 0. \tag{4}$$

Given perfect capital mobility, the interest parity condition holds:

$$i_t = i_t^* + \varepsilon_t, \ \ i_t^* = r + \pi_t^*, \tag{5}$$

where i_t^* is the world nominal interest rate, ε_t is the rate of devaluation (or depreciation) (i.e., $\varepsilon_t \equiv \frac{\dot{E}_t}{E_t}$), and π_t^* is the rate of foreign inflation (i.e., $\pi_t^* \equiv \frac{\dot{P}_t^*}{P_t^*}$). The individual's flow budget constraint (3) and the transversality condition ($\lim_{t\to\infty} a_t e^{-rt} = 0$) yield the individual's lifetime budget constraint:

$$a_0 + \int_0^\infty \left(y^T + \frac{y^N}{e_t} + \tau_t\right) e^{-rt}\, dt = \int_0^\infty \left\{\left(c_t^T + \frac{c_t^N}{e_t}\right) + i_t m_t + s_t\right\} e^{-rt}\, dt. \tag{6}$$

Maximization of the lifetime utility (1) subject to the lifetime budget constraint (6) and taking into account the transactions function (4) yield the following first-order conditions[3] :

$$u'(c_t^T) = \bar{\lambda} \mathcal{P}_t, \tag{7}$$

$$z'(c_t^N) = \frac{1}{e_t} \bar{\lambda} \mathcal{P}_t, \tag{8}$$

and

$$i_t = -v'\left(\frac{m_t}{c_t^T + \frac{c_t^N}{e_t}}\right), \tag{9}$$

where

$$\mathcal{P}_t \equiv 1 + v\left(\frac{m_t}{c_t^T + \frac{c_t^N}{e_t}}\right) - v'\left(\frac{m_t}{c_t^T + \frac{c_t^N}{e_t}}\right) \cdot \left(\frac{m_t}{c_t^T + \frac{c_t^N}{e_t}}\right). \tag{10}$$

$\mathcal{P}_t$ denotes an 'effective' price of tradables consumption, and $\bar{\lambda}$ is the (time-invariant) multiplier associated with the budget constraint (6). The effective price of tradables consumption consists of the good's market price (equal to unity) and the transactions costs incurred by purchasing an additional unit of the good. Therefore, Equations (7) and (8) are the familiar optimality conditions whereby a consumer equates the marginal utility of consumption to the shadow value of wealth, $\bar{\lambda}$, times the effective price of consumption, $\mathcal{P}_t$ and $\frac{\mathcal{P}_t}{e_t}$ for each good. Equation (9) indicates that the consumer equates, at the margin, the decrease in transactions costs that results from holding an additional unit of real money balances to its opportunity cost, i_t. Equation (9) implies the following money demand function:

$$m_t = \left(c_t^T + \frac{c_t^N}{e_t}\right) \cdot l\left(i_t\right), \quad l'(i_t) = -\frac{1}{v''\left(\frac{m_t}{c_t^T + \frac{c_t^N}{e_t}}\right)} < 0. \tag{11}$$

Substitution of Equation (11) into (10) yields

$$\mathcal{P}(i_t) = 1 + v(l(i_t)) - v'(l(i_t)) \cdot l(i_t), \quad \frac{d\mathcal{P}(i_t)}{di_t} > 0, \tag{12}$$

which indicates that the effective price is an increasing function of i_t.

By the first-order conditions (7), (8), and the non-tradable goods market equilibrium condition (i.e., $c_t^N = y^N$), it follows that

$$e_t = \frac{u'(c_t^T)}{z'(c_t^N)} = \frac{u'(c_t^T)}{z'(y^N)}. \tag{13}$$

From the first-order condition (7) and the effective price (12), we have

$$c_t^T = c^T(i_t, \bar{\lambda}), \quad \frac{\partial c^T}{\partial i_t} < 0, \tag{14}$$

along a perfect foresight equilibrium path. Substituting Equations (13) and (14) into the money demand function (11), we can rewrite the money demand function along a perfect foresight equilibrium path as the following:

$$m_t = L(i_t, \bar{\lambda}), \quad \frac{\partial L}{\partial i_t} < 0. \tag{15}$$

2.2 Government

The government's flow budget constraint is given by

$$\dot{h}_t = rh_t + \dot{m}_t + (\pi_t^* + \varepsilon_t)m_t - \tau_t + s_t, \tag{16}$$

where h_t denotes the real stock of foreign assets held by the government (i.e., international reserves). The terms of $\dot{m}_t$ and $(\pi_t^* + \varepsilon_t)m_t$ indicate the government's revenues from money creation. The government is assumed to provide shopping services to consumers and transfer back the proceeds from such an activity to the consumer in a lump-sum way. In other words, the transactions costs are assumed to be a private rather than a social cost[4] . The government's lifetime budget constraint is given by

$$\int_0^\infty \tau_t e^{-rt} dt = h_0 + \int_0^\infty (\dot{m}_t + \varepsilon_t m_t + \pi_t^* m_t + s_t) e^{-rt} dt. \tag{17}$$

The government's lifetime budget constraint indicates that the present value of transfers must equal the initial stock of international reserves, denoted by h_0, and revenues from money creation.

Let μ_t denote the rate of nominal domestic credit creation:

$$\frac{\dot{D}_t}{D_t} = \mu_t, \tag{18}$$

where D_t denotes nominal domestic credit. From the central bank's balance sheet, we have

$$m_t = h_t + d_t, \tag{19}$$

where $d_t \left(= \frac{D_t}{P_t^* E_t}\right)$ denotes real domestic credit. It follows that

$$\dot{m}_t = \dot{h}_t + \dot{d}_t. \tag{20}$$

Furthermore, from the definition of d_t, we obtain the rate of real domestic credit creation:

$$\frac{\dot{d}_t}{d_t} = \mu_t - \varepsilon_t - \pi_t^*. \tag{21}$$

2.3 The Initial Steady State

Combining the individual's (flow) budget constraint (3) and the government (flow) budget constraint (16), and using the interest parity condition (5) and the equilibrium condition of the non-tradable goods market (i.e., $c_t^N = y^N$) yield the economy's resource constraint:

$$\dot{k}_t = rk_t + y^T - c_t^T, \tag{22}$$

where $k_t (\equiv b_t + h_t)$ is the economy's net stock of foreign assets. The economy's resource constraint also indicates the current account. Similarly, from the individual's (lifetime) budget constraint (6), the government (lifetime) budget constraint (17), the non-tradable goods market equilibrium condition ($c_t^N = y^N$), the interest parity condition (5), and the transversality condition: $\lim_{t\to\infty} k_t e^{-rt} = 0$, we obtain the economy's lifetime resource constraint:

$$k_0 + \frac{y^T}{r} = \int_0^\infty c_t^T e^{-rt} dt. \tag{23}$$

The central bank is assumed to fix the exchange rate at a level $\bar{E}$ in the *initial* steady state. It is also assumed that the public know that the fixed exchange rate regime will remain in place (i.e., $\varepsilon_t = 0$) as long as international reserves are positive. Once the international reserves reach zero, however, the government is assumed to abandon the peg and shift to the flexible exchange rate regime.

In the initial steady state, the world nominal interest rate (i_t^*) is assumed to be a constant $i_0^*(= r + \pi_0^*)$. By the interest parity condition (5), it implies that under fixed exchange rates, the equilibrium level of the nominal interest rate is also constant over time (i.e., $i_t = r + \pi_0^*$). The first-order condition (7) and Equation (12) imply that tradables consumption must be constant over time. Thus, from the economy's resource constraint (23), we obtain

$$c_t^T = rk_0 + y^T, \tag{24}$$

which indicates that consumption of tradable goods equals the annuity value of lifetime income of tradable goods. As for the monetary equilibrium, from the money demand function (15), we can know that money demand also must be constant over time.

2.4 The Government's Domestic Credit Policy

In the initial steady state, a model consistent with fixed exchange rates must have $\dot{d}_t = 0$ in Equation (21), which implies

$$\bar{\mu} = \pi_0^*. \tag{25}$$

Otherwise, it would lead to a continuous loss (or gain) of international reserves. That is, in the initial steady state the international reserves h_t, the domestic credit d_t, and the real money balances m_t must remain constant.

We assume that the government always keeps the domestic credit policy $\bar{\mu} = \pi_0^*$. This assumption of the fixed domestic credit policy reflects the government's passive attitude characterizing the classical generation model of BOP crises. In the classical generation model represented by Krugman (1979), the government is a passive agent. The government does not change its initial policy of domestic credit creation, and then sits defenselessly as it watches the households rushing to the central bank and exchanging the domestic money with the international reserves.

3. A Permanent Decrease in the World Nominal Interest Rate

In this section, we examine how an unanticipated and permanent decrease in the world nominal interest rate (but no change in the *real* world interest rate) brings about BOP crises. For the sake of definiteness, we assume that up to time zero (i.e., the "present"), the economy has been in the steady state with the constant world nominal interest rate i_0^*. At time zero, an unanticipated permanent decrease in the world nominal interest rate takes place. All participants know that from $t = 0$ (to $t = +\infty$) the world nominal interest rate is at the level of i_L^*, where $i_L^* < i_0^*$. This permanent decrease in the world nominal interest rate is depicted in Figure 1. Formally, it is assumed that

$$i_t^* = \begin{cases} i_0^* = r + \pi_0^*, & (t < 0) \\ i_L^* = r + \pi_L^*. & (0 \leq t) \end{cases} \tag{26}$$

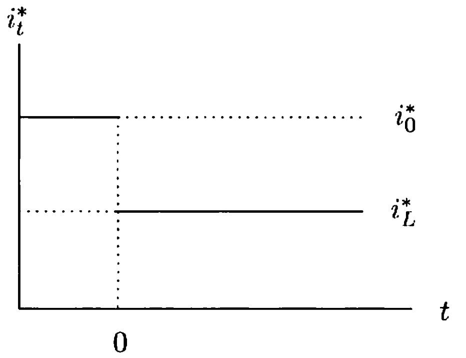

Figure 1 The world nominal interest rate

Since the government keeps the domestic credit policy of setting $\bar{\mu} = \pi_0^*$ as mentioned in the last section, by Equation (21), we obtain that

$$\dot{d}_t = d_t(\bar{\mu} - \pi_L^*) > 0. \tag{27}$$

A fall in the world nominal interest rate from i_0^* to i_L^* causes real domestic credit to start increasing as depicted in Figure 2. As long as the fixed exchange rate regime remains in place, the nominal interest rate remains constant by Equation (5). By the money demand function (15), therefore, the level of real money balances m_t is constant during the corre-

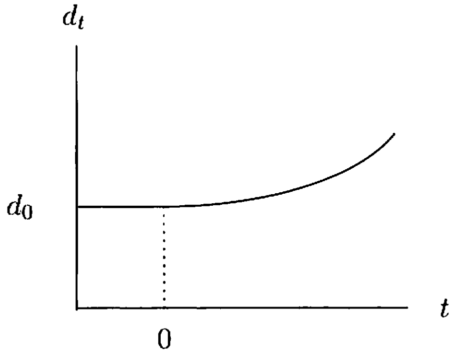

Figure 2 Real domestic credit

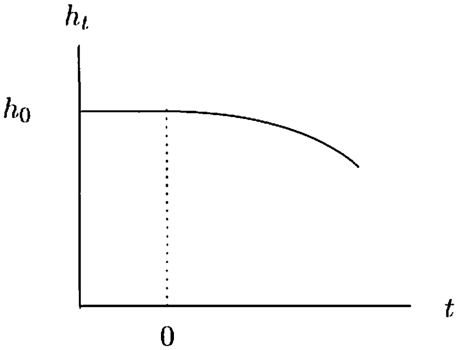

Figure 3 International reserves

sponding time interval. It follows from Equation (20) that the level of international reserves begins to decrease as illustrated in Figure 3.

Consumers know that international reserves will be exhausted (i.e., go to zero) in a finite time and the central bank will let the exchange rate float. Let T denote the instant when a BOP crisis occurs. After the crisis occurs, the central bank will shift to a floating exchange rate regime. The appendix A shows that immediately after the crisis the nominal interest rate must adjust to the steady state level i_{ss}:

$$i_{ss} = r + \pi_0^*. \tag{28}$$

Hence, consumers know that the time path of the nominal interest rate must look like as in Figure 4. Formally, we obtain that

$$i_t = \begin{cases} i_L = r + \pi_L^* = i_L^*, & (0 \leq t < T) \\ i_0 = r + \pi_0^* = i_0^*. & (T \leq t) \end{cases} \tag{29}$$

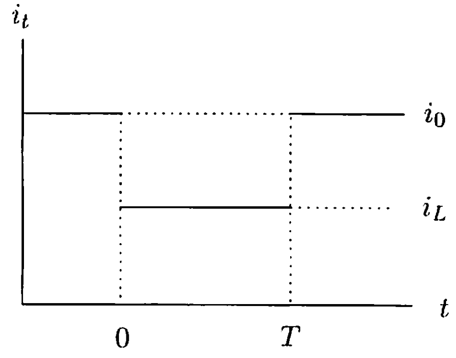

Figure 4 The nominal interest rate

Hence, Equations (26) and (29), and the interest parity condition (5) yield the time profile of the depreciation rate of the nominal exchange rate shown in Figure 5. Formally, we obtain that

$$\varepsilon_t = \begin{cases} 0, & (t < T) \\ \pi_0^* - \pi_L^*. & (T \leq t) \end{cases} \tag{30}$$

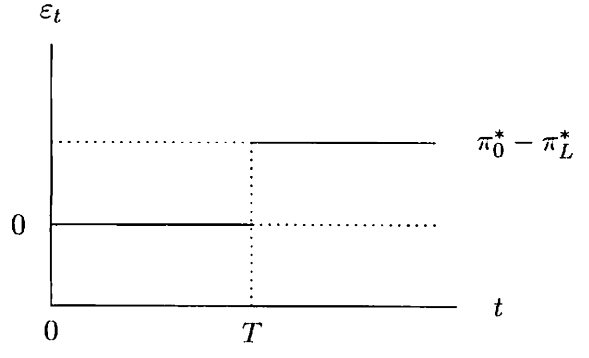

Figure 5 The depreciation rate of the nominal exchange rate

From the money demand function (15) and the time path of the nominal interest rate, it follows that at time T the real money balances m_t falls from m_L to m_T as depicted in Figure 6, where m_L and m_T respectively denote

$$m_L = L(i_L, \bar{\lambda}), \tag{31}$$

and

$$m_T = L(i_0, \bar{\lambda}). \tag{32}$$

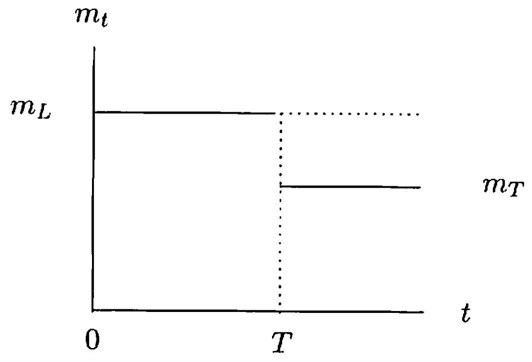

Figure 6 Real money balances

Since under flexible exchange rates $h_t = 0$ and $\dot{h}_t = 0$, we have

$$m_t = d_t. \tag{33}$$

From the time of the BOP crisis, T, the exchange rate starts floating. However, the nominal exchange rate can not jump along a perfect foresight equilibrium path (i.e., $0 < t$). If it did, there would be infinite arbitrage opportunities. Hence, by Equation (33), this implies that the money market equilibrium at T is given by

$$m_T = L(i_0, \bar{\lambda}) = d_T = \frac{D_T}{\bar{E}}. \tag{34}$$

Furthermore, by Equation (27), we obtain

$$\frac{D_T}{\bar{E}} = \frac{D_0 \exp\{(\bar{\mu} - \pi_L^*)T\}}{\bar{E}} = \frac{D_0 \exp\{(i_0^* - i_L^*)T\}}{\bar{E}}. \tag{35}$$

Thus, Equations (34) and (35) give

$$L(i_0, \bar{\lambda}) = \frac{D_0 \exp\{(i_0^* - i_L^*)T\}}{\bar{E}}, \tag{36}$$

which implicitly defines the time of collapse T as a function of i_L^*, D_0, and $\bar{\lambda}$:

$$T = T(i_L^*, D_0, \bar{\lambda}), \tag{37}$$

where

$$\frac{dT}{di_L^*} > 0, \ \frac{dT}{dD_0} < 0, \tag{38}$$

for a given i_0^*. Equation (38) indicates that the time of a crisis is hastened, as the size of the decrease from i_0^* to i_L^* becomes larger. In addition, an implication of the classical generation model is true in this model. That is, the government with a high initial level of domestic credit easily suffers from BOP crises.

By Equation (27), real domestic credit starts increasing at time 0. However, from Equation (33) and the fact that the equilibrium level of real money balances is constant after the crisis, it follows that d_t becomes constant after the crisis as well. Figure 7 depicts the time path of real domestic credit.

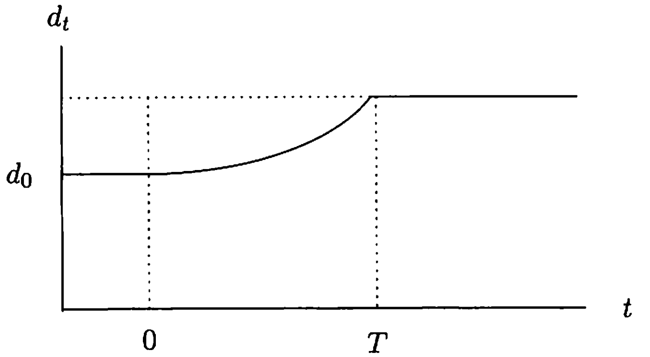

Figure 7 Real domestic credit

The discrete change in real money demand at the moment of the crisis T is given by

$$\Delta m_T \equiv m_T - m_{T-} = m_T - m_L = L(i_0, \bar{\lambda}) - L(i_L, \bar{\lambda}) < 0, \tag{39}$$

where $T-$ indicates an instant before the crisis. From the central bank's balance sheet, this discrete change in real money demand at T corresponds to the loss in international reserves because d_t can not jump at T. The speculative attack occurs when the stock of international reserves exactly matches the desired change in real money demand. At the time T, a speculative attack run depletes the stock of international reserves (i.e., $\Delta m_T = \Delta h_T$). Hence, the time paths of real money balances and real domestic credit, and the central bank's balance sheet (i.e., $h_t = m_t - d_t$) yield the time path of international reserves illustrated in Figure 8.

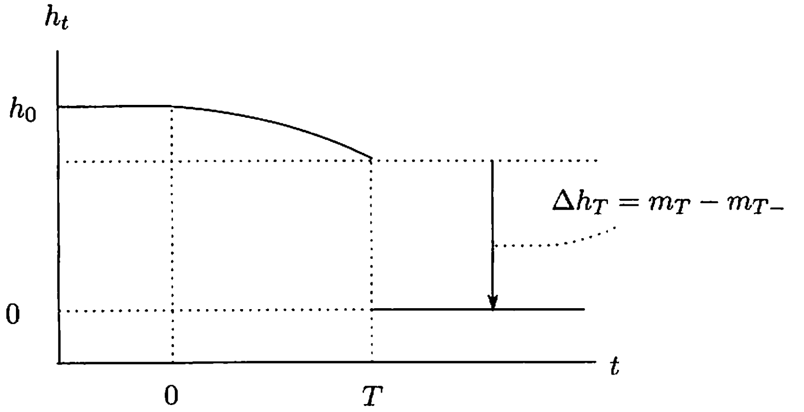

Figure 8 International reserves

From the time path of the nominal interest rate i_t, the first-order condition (7), and Equation (12), the equilibrium level of tradables consumption during 0 and T must be higher than that after T. Intuitively, this is because the low nominal interest rate from 0 to T reduces the effective price of tradables consumption. Furthermore, to satisfy the economy's resource constraint (23), the initial level of tradables consumption before 0 must be placed between the level from 0 to T and that after T[5]. Hence, we obtain the time path of tradables consumption illustrated in Figure 9.

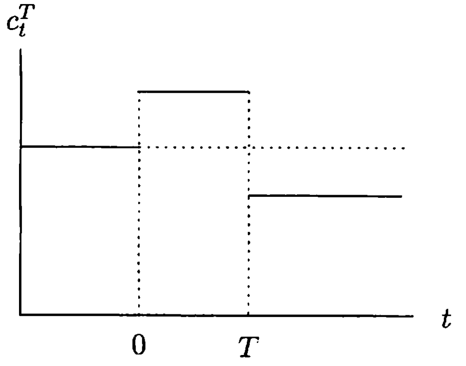

Figure 9 Consumption of tradable goods

By Equation (22), the increase in tradables consumption at 0 causes the current account deficit. The current account deteriorates through the time interval from 0 to T since debt service increases (or interest income on foreign assets decreases). Figure 10 depicts the time path of the current account.

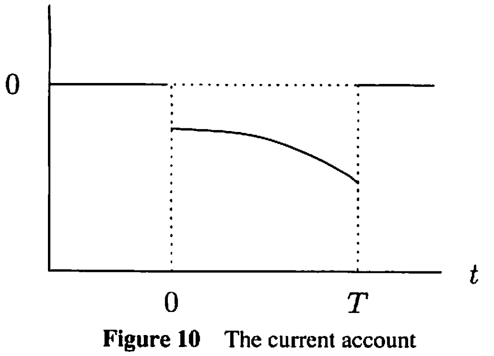

Figure 10 The current account

The time path of tradables consumption and Equation (13) yield the time path of the real exchange rate e_t illustrated in Figure 11. It indicates that the real exchange rate appreciates during the time interval between 0 and T before the crisis.

Since by definition the real exchange rate is

$$e_t = \frac{E_t P_t^*}{P_t^N}, \tag{40}$$

it follows that

$$\pi_t = -\frac{\dot{e}_t}{e_t} + \varepsilon_t + \pi_t^*, \tag{41}$$

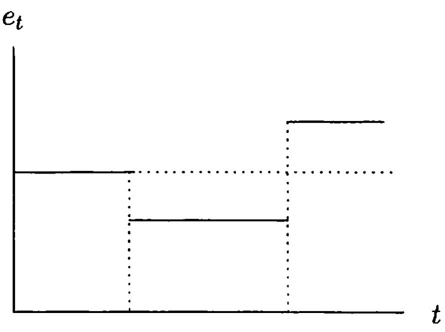

Figure 11 The real exchange rate

where π_t is the inflation rate of non-tradable goods (i.e., $\pi_t \equiv \frac{\dot{P}_t^N}{P_t^N}$).

From Equation (41), and the time paths of e_t, ε_t, and π_t^*, we obtain the time path of π_t illustrated in Figure 12. Hence, from Equation (40) and the time paths of e_t and π_t, it follows that the time path of $\ln P_t^N$ must look like as illustrated in Figure 13[6] .

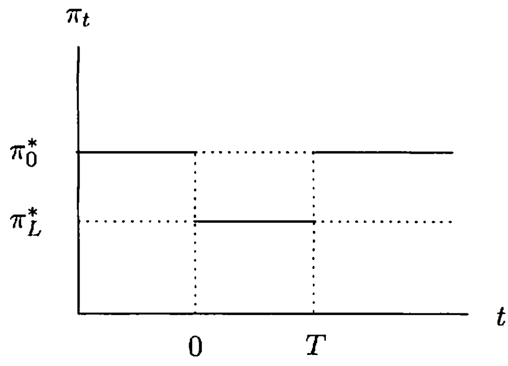

Figure 12 The inflation rate of non-tradable goods

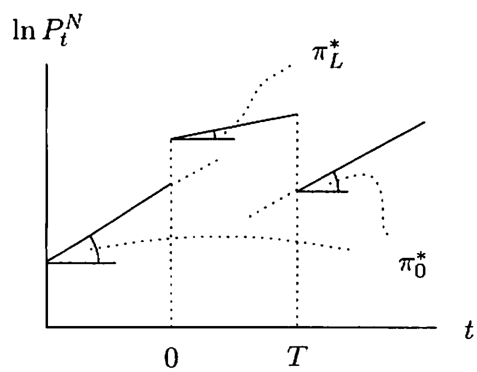

Figure 13 The price of non-tradable goods

From Equation (30) and the fact that the nominal exchange can not jump in an anticipated way along a perfect foresight equilibrium path, we obtain the time path of the nominal exchange rate depicted in Figure 14.

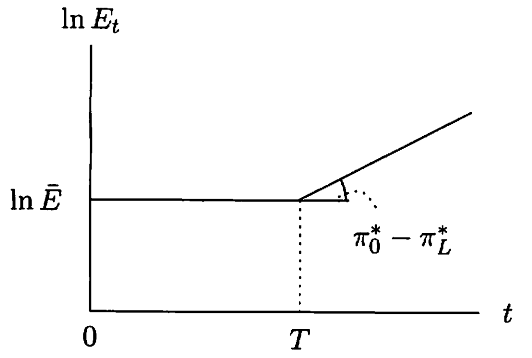

Figure 14 The nominal exchange rate

4. The Size of a Shock and Its Macroeconomic Effects

This section examines how the size of the external shock influences the degree of its macroeconomic effects (i.e., the degree of the current account deficit, the real exchange rate appreciation, and inflationary pressures) and the time of a BOP crisis. Since a closed form of the equilibrium level of tradables consumption is more convenient for this purpose, we specify the utility function as the following[7] :

$$\int_0^\infty \{\ln(c_t^T) + \ln(c_t^N)\}e^{-\beta t}\, dt. \tag{42}$$

The external shock's size is defined as the degree of a decrease in the world nominal interest rate (i.e., $i_0^* - i_L^*$). Since i_0^* is given, it amounts to consider the effects of i_L^* on the macroeconomic variables. In Equation (37), therefore, we denote the time of collapse as a function of i_L^* (i.e., $T = T(i_L^*)$). As argued already, we have Equation (38):

$$\frac{dT}{di_L^*} > 0,$$

which indicates that the time of a BOP crisis is hastened, as the degree of the decrease from i_0^* to i_L^* becomes larger. The appendix B shows the closed form for the equilibrium level of tradables consumption between 0 and T denoted by c_1^T:

$$c_1^T = \frac{rk_0 + y^T}{1 - e^{-r\,T(i_L^*)} + q(i_L^*)\; e^{-r\,T(i_L^*)}}, \tag{43}$$

where $q(i_L^*)$ is defined as

$$q(i_L^*) \equiv \frac{\mathcal{P}(i_L^*)}{\mathcal{P}(i_0^*)}. \tag{44}$$

Differentiating Equation (43) with respect to i_L^* (for a given i_0^*), we obtain

$$\frac{dc_1^T}{di_L^*} = \frac{\partial c_1^T}{\partial T}\frac{dT}{di_L^*} + \frac{\partial c_1^T}{\partial q}\frac{dq}{di_L^*} < 0, \tag{45}$$

where $\frac{dT}{di_L^*} > 0$ (by Equation (38)) and $\frac{dq}{di_L^*} > 0$ (by Equations (12) and (29))[8] . Equation (45) indicates that the equilibrium level of tradables consumption from 0 to T deviates from its initial steady state level, as the degree of a fall in the world nominal interest rate at time $t = 0$ becomes greater (i.e., the lower i_L^*, the higher c_1^T.). By Equation (22), this implies that the current account deficit at time $t = 0$ also becomes larger, as the size of shock becomes larger. Throughout the low nominal interest rate interval from 0 to T, the current account deteriorates further, since debt service increases (or interest income on foreign assets decreases). In Figure 15, T' corresponds to a larger shock than T".

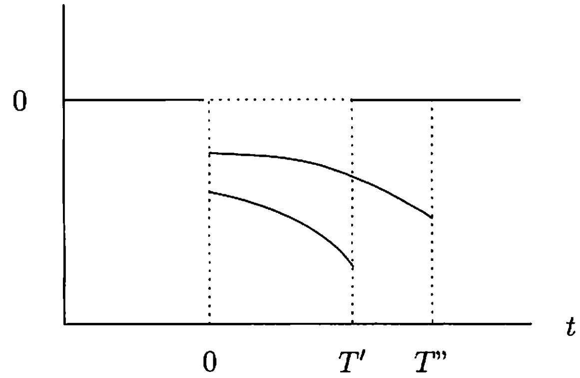

Figure 15 The current account

It follows from Equation (13) that the higher c_1^T is, the larger the jump of e_t at time $t = 0$ becomes. This implies that as the external shock becomes larger, an economy will experience a greater appreciation in the real exchange rate during the time interval between 0 and T. In addition, by Equation (40), the larger the jump of e_t at time $t = 0$ is, the larger the discrete change of $\ln P_t^N$ at time 0 becomes. This implies that the economy will experience a greater inflationary pressure during the time interval between 0 and T, as the size of the external shock becomes larger.

5. Conclusion

This paper has developed a model of BOP crises triggered by external factors. It has shown that a decrease in the world nominal interest rate triggers a BOP crisis in a small open economy. The crisis is explained as well as the macroeconomic phenomena such as a deterioration in the current account and an appreciation in the real exchange rate that preceded the crises in the emerging markets in Latin America and East Asia in the 1990s. In addition, the model explains inflationary pressures evident especially in Latin America. The model has a theoretical implication that a larger shock brings about a larger current account deterioration, a greater real exchange rate appreciation, and a higher inflationary pressure, hastening the time of the BOP crisis.

Appendix A

Substituting (10) and (13) into (7) and taking into account the non-tradables equilibrium condition (i.e., $y^N = c_t^N$) yield $\frac{dc_t^T}{dm_t}$ as the following:

$$\frac{dc_t^T}{dm_t} = \frac{\left(\frac{m_t}{c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}}\right) v''(\cdot)}{-\frac{u''(c_t^T)}{u'(c_t^T)}\mathcal{P}_t\left(c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}\right) + v''(\cdot)\left(1 - \frac{y^N z'(y^N)}{u'(c_t^T)^2}u''(c_t^T)\right)\left(\frac{m_t}{c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}$$
$$> 0. \tag{46}$$

Hence, m_t and c_t^T move in the same direction along a perfect foresight equilibrium path.

After the BOP crisis, the central bank shifts to the floating exchange rate regime. Since $h_t = 0$ and $\dot{h}_t = 0$, we have $m_t = d_t$ under flexible exchange rates. It follows that

$$\frac{\dot{m}_t}{m_t} = \frac{\dot{d}_t}{d_t} = \mu_t - \varepsilon_t - \pi_t^*. \tag{47}$$

Since the government is assumed to set μ as π_0^* in the initial steady state and not to alter this domestic credit policy ($\bar{\mu} = \pi_0^*$), we have

$$\frac{\dot{m}_t}{m_t} = \bar{\mu} - \varepsilon_t - \pi_t^* = \pi_0^* - \varepsilon_t - \pi_t^*. \tag{48}$$

From the interest parity condition (5), Equation (48) can be rewritten as

$$\frac{\dot{m}_t}{m_t} = \pi_0^* + r - i_t. \tag{49}$$

Furthermore, substituting (13) into the first-order condition (9) and differentiating it with respect to time yield

$$\dot{i}_t = -v''(\cdot)\left\{\frac{1}{c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}}\dot{m}_t - \frac{m_t}{\left(c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}\right)^2}\left(1 - \frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\dot{c}_t^T\right\}. \tag{50}$$

Here, Equation (46) gives

$$\dot{i}_t = -v''(\cdot)\left(\frac{1}{c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}}\right)$$
$$\times\left[1 - \frac{v''(\cdot)\left(1 - \frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}{-\frac{u''(c_t^T)}{u'(c_t^T)}\mathcal{P}_t\left(c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}\right) + v''(\cdot)\left(1 - \frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}\right]\dot{m}_t. \tag{51}$$

Finally, substitution of (49) into (51) gives the following differential equation of i_t:

$$\dot{i}_t = v''(\cdot)\left(\frac{m_t}{c_t^T + \frac{y^N z'(y^N)}{u'(c_t^T)}}\right)$$

$$\times\left[1-\frac{v''(\cdot)\left(1-\frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}{-\frac{u''(c_t^T)}{u'(c_t^T)}\mathcal{P}_t\left(c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}\right)+v''(\cdot)\left(1-\frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}\right]$$
$$\times(i_t-r-\pi_0^*). \tag{52}$$

It follows that

$$i_{ss}=r+\pi_0^*,$$

where i_{ss} denotes the steady state level of i_t. Differentiating Equation (52) with respect to i_t around the steady state yields

$$\frac{\partial\dot{i}_t}{\partial i_t}|_{ss}=v''(\cdot)\left(\frac{m_t}{c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}}\right)$$
$$\times\left[1-\frac{v''(\cdot)\left(1-\frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}{-\frac{u''(c_t^T)}{u'(c_t^T)}\mathcal{P}_t\left(c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}\right)+v''(\cdot)\left(1-\frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}\right]>0. \tag{53}$$

Note that

$$0<\frac{v''(\cdot)\left(1-\frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}{-\frac{u''(c_t^T)}{u'(c_t^T)}\mathcal{P}_t\left(c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}\right)+v''(\cdot)\left(1-\frac{y^N z'(y^N)u''(c_t^T)}{u'(c_t^T)^2}\right)\left(\frac{m_t}{c_t^T+\frac{y^N z'(y^N)}{u'(c_t^T)}}\right)^2}<1.$$

From (53), we can know that i_t follows an unstable differential equation. Hence, at time $t=T$ (i.e., the time when a BOP crisis occurs), i_t must adjust to its steady state level instantaneously. Otherwise, it would diverge as illustrated in Figure 16. Hence, after the crisis, i_t must remain in the steady state value (i.e., $i_{ss}=r+\pi_0^*$) over time along a perfect foresight equilibrium path.

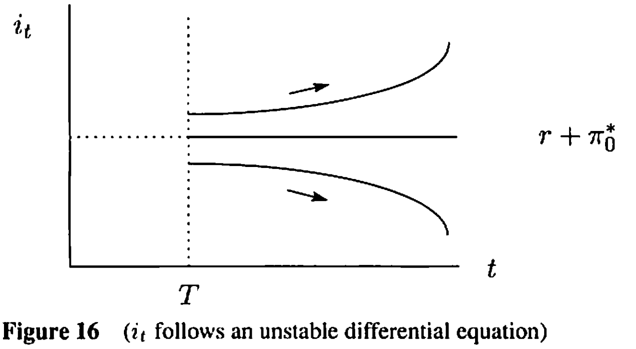

Figure 16 (i_t follows an unstable differential equation)

Appendix B

Let c_1^T denote the equilibrium level of tradables consumption associated with the low nominal interest rate (i_L) between 0 and T, and c_2^T that of tradables consumption associated with the high nominal interest rate (i_0) after T. By Equation (37), the time of the crisis T depends on i_L^* for a given i_0^*. Then, by (23), it follows that

$$\int_0^{T(i_L^*)} c_1^T e^{-rt} dt + \int_{T(i_L^*)}^{\infty} c_2^T e^{-rt} dt = k_0 + \frac{y^T}{r}. \tag{54}$$

By the first-order condition (7) and Equations (12) and (29), we obtain Equation (44):

$$\frac{c_2^T}{c_1^T} = \frac{\mathcal{P}(i_L)}{\mathcal{P}(i_0)} = \frac{\mathcal{P}(i_L^*)}{\mathcal{P}(i_0^*)} \equiv q(i_L^*),$$

for a given i_0^*. Substitution of (44) into (54) gives the closed form of c_1^T:

$$c_1^T = \frac{r k_0 + y^T}{1 - e^{-r\, T(i_L^*)} + q(i_L^*) e^{-r\, T(i_L^*)}}.$$

Notes

1 For the stabilization policy and related issues, see Calvo and Végh (1999).

2 See McCallum and Goodfriend (1987), Lucas (1993), and Feenstra (1986) for general arguments on transactions costs. As for a similar type of transactions-costs technologies, see, for instance, Reinhart (1990) and Reinhart and Végh (1995) among others.

3 To abstract from intrinsic sources of an economy's dynamics, the model assumes that $\beta = r$. The intrinsic source of dynamics causes a movement even when all exogenous variables that affect the economy are expected to remain constant forever. In other words, the model focuses on the extrinsic dynamic behavior caused by the changes of the world interest rate. This distinction between the intrinsic and extrinsic dynamics is made by Obstfeld and Stockman(1985). Samuelson(1947) also calls this kind of distinction as that between "causal" and "historical" dynamic systems.

4 This assumption enables us to isolate the effect of intertemporal consumption substitution. If the transactions costs are costly from a social point of view, a temporary decrease in the nominal interest rate has a positive wealth effect. See, for example, Reinhart and Végh (1995) for this assumption's rationale.

5 Note that a change in the nominal interest rate (but no change in the *real* interest rate) does not affect the resource constraint.

6 E_t in Equation (40) can not jump along a perfect foresight equilibrium path. P_t^* also does not jump by assumption, although π_t^* jumps. Therefore, when e_t jumps, P_t^N must jump to absorb the shock.

7 The results of our analysis are robust even in the case of a more general form of utility function such as the constant intertemporal elasticity of substitution (CIES) utility function.

8 Using Equation (43), by simple calculations, we also obtain

$$\frac{\partial c_1^T}{\partial T} < 0, \quad \frac{\partial c_1^T}{\partial q} < 0.$$

List of Variables

E_t=nominal exchange rate;
P_t=domestic price level of tradable goods;
P_t^*=foreign price level of tradable goods;
c_t^T=consumption of tradable goods;
c_t^N=consumption of non-tradable (or home) goods;
y^T=a constant endowment flow of tradable goods;
y^N=a constant endowment flow of non-tradable goods;
m_t=real money balances;
b_t=real private foreign asset holdings;
a_t=real financial wealth of a consumer;
r=the (constant) world real interest rate;
τ_t=the government's lump-sum trasfer;
i_t=(domestic) nominal interest rate;
P_t^N=price of non-tradable goods;
e_t=real exchange rate;
s_t=transactions costs;
i_t^*=the world nominal interest rate;
ε_t=the rate of devaluation (or depreciation);
π_t^*=the rate of foreign inflation;
$\mathcal{P}_t$=effective price of tradables consumption;
h_t=international reserves;
d_t=real domestic credit;
μ_t=the rate of nominal domestic credit creation;
k_t=the economy's net stock of foreign assets;
π_t=inflation rate of non-tradable goods.

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