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RESEARCH ARTICLE

The Simple Analytics of Sudden Stops

Peter J. Montiel

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Abstract Currency crises in emerging and developing countries have often been characterized by "sudden stops" of capital flows. A variety of mechanisms have been adduced to explain the emergence of this phenomenon. This paper integrates these mechanisms into a simple and transparent analytical model in which currency mismatches, large current account deficits, and large stocks of short-term debt interact with low reserve stocks to generate dual equilibria. In this context, the "panic" equilibrium is characterized by a currency crisis, a sudden stop, and an output collapse. The potential for various policies to avoid this outcome is explored, as are the implications of the analysis for reserve accumulation.

Keywords Currency crises · Mismatches · Multiple equilibria · Sudden stops

JEL F32 · F41

1 Introduction

The large number of currency crises that have occurred over the past three decades has led to a proliferation of analytical models attempting to explain their causes. As the characteristics of these crises have changed, the models used to analyze them have done so as well. "First-generation" models, based on Krugman (1979), were based on a mechanical inconsistency between a fixed exchange rate and an expansionary monetary policy driven by the financing needs of the government. "Second-generation" models, by contrast, considered the abandonment of an existing nominal parity as the optimizing decision of a central bank faced with a conflict between maintaining the existing parity and other desirable macroeconomic objectives. The experience of the 1997–98 Asian financial crisis gave rise to yet a new generation of models featuring a variety of phenomena not incorporated into the earlier literature, including moral hazard, currency mismatches in the balance sheets of domestic agents, and capital flow reversals.

P. J. Montiel (✉)
Williams College, Williamstown, USA
e-mail: Peter.J.Montiel@williams.edu

It has increasingly been recognized that capital-flow reversals in particular, despite their omission from first- and second-generation models, have played an important role in many currency crises, including many that predated the 1997–98 Asian crisis. Yet currency crises and capital-flow reversals are distinct phenomena – i.e., not all currency crises occur in the context of a capital-flow reversal, and not all capital-flow reversals are accompanied by currency crises (Hutchison and Noy 2006).[1] Advanced economies, for example, do not typically tend to lose access to international capital markets in the midst of currency crises. On the other hand, reversals are a more common feature of emerging-market currency crises. This coincidence of a currency crisis with a capital-flow reversal has been dubbed a "sudden stop" by Calvo (1998).

Because sudden stops tend to have dramatic negative consequences for the economies that endure them, their determinants and consequences have been explored extensively. A common finding concerning the domestic antecedents of sudden stops is that they tend to feature extensive domestic liability dollarization (more specifically, currency mismatches) and large trade deficits.[2] Sudden stops have been found to be more common when these two factors coincide (Calvo et al. 2008). Other antecedents of sudden stops identified in the literature include large pre-crisis capital inflows, especially when these are dominated by short-term flows, currency overvaluation, and large ratios of broad money and/or short-term external debt to international reserves.

A different strand of literature has examined the macroeconomic consequences of sudden stops. In addition to a cessation of capital inflows, such crises have been characterized by large capital outflows on the part of domestic residents, current account reversals, significant real exchange rate depreciation, systemic banking system failures, corporate bankruptcies, and large output contractions (see Calvo and Reinhart 2000; Hutchison and Noy 2006; Guidotti et al. 2004, and Calvo et al. 2008).

While several models have been developed to analyze the determinants and consequences of sudden stops (see, for example, Cavallo 2005, as well as Caballero and Krshnamurthy 1998, among others), such models typically focus on a subset of the phenomena that have been empirically identified as important determinants of sudden stops. The objective of this paper, by contrast, is to describe a simple, generic "third generation" currency crisis model that weaves these diverse elements together, thereby integrating several of the factors that have featured prominently in professional analysis of the causes of sudden stops into a simple and coherent analytical framework. In particular, the model assigns prominent roles to transactions driven by moral hazard, to currency mismatches in the balance sheets of domestic agents in the crisis countries, to current account deficits, to the maturity composition of capital flows, and to the stock of reserves relative to the money stock.

[1] Note that capital-flow reversals need not be associated with *current account* reversals if central banks are willing and able to finance current account deficits by selling reserves. Only if they are *not* so willing would the exchange rate have to move, thus potentially resulting in a currency crisis. Reserve depletion thus potentially breaks the link between capital flow reversals and currency crises by breaking the link between capital-flow and current account reversals. This mechanism figures prominently in the model developed in this paper. For the empirical relationship between capital-flow reversals and current-account reversals, see Edwards (2004).

[2] External triggers have also been explored, of course (Mody and Taylor 2002, for example, consider advanced-country interest rates, growth and high-yield spreads, while others have examined the effects of contagion from crises elsewhere), but these are less relevant for present purposes.

It is characterized by the possibility of multiple equilibria and, as a byproduct, yields a set of hypotheses concerning the determinants of reserve accumulation.

1.1 A Simple "monetary approach" Framework

A useful starting point for a "generic" crisis model is the identity describing a country's overall balance of payments. I will write this identity in the form:

$$\Delta R = \underset{++}{B(\theta, s)} - (i * + \gamma) D_0 + F - K. \tag{1}$$

Here B is the trade surplus (measured in dollars), which is written as a function of the fixed (nominal) exchange rate s and an exogenous shift parameter θ; i^* is the interest rate on the county's external debt (rendered exogenous by the small country assumption); γ is the share of predetermined external debt D that has to be amortized each period (note that γ must therefore be larger the larger the share of short-term debt in the country's total external liabilities); F represents new lending to the domestic economy by foreign agents (capital inflows), and K is new lending to foreigners by domestic residents (non-amortization capital outflows). I will describe the determination of F and K below. Notice that the inclusion of the gross (rather than the net) stock of external debt as the source of net interest payment to the rest of the world involves the implicit assumption that the external assets acquired by domestic residents through capital outflows K do not pay interest. I will retain that simplifying assumption in what follows. The definitions above imply that the stock of external debt must evolve according to:

$$\Delta D = F - \gamma D. \tag{2}$$

For notational convenience, it will be useful to rewrite (1) as:

$$\Delta R = \Delta R_A + F - K, \tag{1'}$$

where $\Delta R_A = B(\theta, s) - (i * + \gamma) D_0$ is the "autonomous" component of the balance of payments – i.e., it is the portion of the balance of payments that depends only on predetermined, exogenous, or policy variables.

Next, consider the determination of capital inflows F and non-amortization capital outflows K. As we will see below, it will be necessary to distinguish between "normal" times and "panics." Leaving the latter to the next section, then, consider the determination of F and K during normal times.

Normal times are characterized by the condition that all domestic debts are expected to be serviced on the contractually-agreed terms. I will assume that the value of capital inflows (F) during such times is exogenous, and will explore below the implications of alternative assumptions about the magnitude of such inflows. But what determines K under these circumstances? From the central bank's balance sheet the overall balance of payments can be expressed in the traditional "monetary approach to the balance of payments" (MABP) form as:

$$s\Delta R - \left(M^D - M_0\right) - \Delta DC, \tag{3}$$

where M^D and M_0 are respectively the end-of-period money demand and beginning-of-period money supply, so (M^D - M_0) represents "hoarding" (a flow demand for additions to the money stock) by domestic agents. ΔDC is the flow supply of domestic credit extended by the central bank, a policy variable.

I will take the end-of-period demand for money to be exogenous during "normal" times. Under this assumption, since M_0 is predetermined and ΔDC can be taken to be a policy variable, Eq. (3) determines the overall balance of payments during normal times. Again for notational simplicity, we can express the equilibrium value of the balance of payments, measured in foreign-currency terms, as:

$$\Delta R = EDM, \tag{3'}$$

where $EDM = [M^D - (M_0 + \Delta DC)]/s$ is the domestic (flow) excess demand for money, measured in units of the foreign currency.

It follows that "normal" non-amortization capital outflows from domestic residents, denoted K_N, represent the residual item that reconciles the overall balance of payments to its remaining components:

$$\begin{aligned} K_N &= \Delta R_A + F + [(M_0 - M^D) + \Delta DC]/s. \\ &= \Delta R_A + F - EDM, \end{aligned} \tag{4}$$

Thus, given *EDM*, changes in the autonomous component of the balance of payments or in capital inflows are offset one-for-one during normal times by changes in the volume of capital outflows, thereby permitting the private sector continuously to hold its desired stock of money.

The workings of this model during normal times are illustrated in Fig. 1. The official exchange rate is identified by the horizontal line s_0. Since the overall balance of payments, as determined by (3′), is independent of the exchange rate, it is represented by the vertical line at ΔR_0. The set of all combinations of R and s that are consistent with the balance of payments identity, as given by Eq. (1′), for given values of F and K, can be depicted as an upward-sloping BP locus in this figure. Its positive slope arises from the assumed positive effect of exchange rate depreciation on the trade balance, which is a component of the autonomous portion of the balance of payments ΔR_A. We would expect this curve to be flatter the more sensitive the trade balance is to the exchange rate – i.e., the more open the domestic goods market. The balance of payments locus must pass through the point A, where the lines through s_0 and ΔR_0 intersect. Since changes in K shift this locus horizontally, the equilibrium value of K, denoted K_0 in the figure, is determined by the requirement that the balance of payments locus must pass through A. Thus, given the official exchange rate and the overall balance of payments outcome, nonamortization private capital outflows are simply determined by the other components of the balance of payments, as in the MABP.

It is easy to see that changes in the flow demand for money or in monetary policy would simply shift the vertical ΔR locus to the right or left, altering the equilibrium outcome for the balance of payments. The new balance of payments outcome is accommodated by a change in capital outflows K that causes the BP locus to shift so that it passes through the new intersection of s_0 and ΔR. Changes in the autonomous component of the balance of payments (other than exchange rate changes) or in

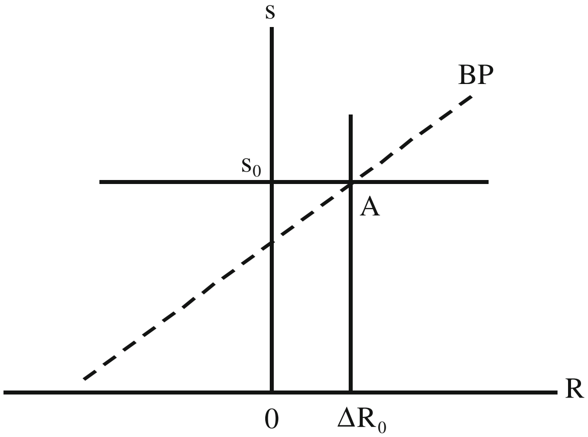

Fig. 1 Balance of payments equilibrium during normal times

capital inflows, on the other hand, would simply result in offsetting movements in capital outflows, leaving the balance of payments outcome unchanged and thus leaving all of the curves in Fig. 1 undisturbed.

What has just been described is the simplest version of a standard "monetary approach" model. This is the basic framework underlying "first generation" crisis stories. It is easy to see how such a crisis would be triggered in the present context. All that is required is a rate of expansion of domestic credit ΔDC that exceeds the flow demand for money M^D - M_0 and an exchange regime "rule" that causes the central bank to switch to a floating exchange rate when the stock of reserves reaches a lower bound. The former ensures that the stock of reserves will be falling over time, while the latter ensures that this reserve path will be associated with a regime switch.

It is useful to consider several aspects of this simple and familiar "first generation" crisis story. First, none of the factors that affect the autonomous component of the balance of payments plays any role in determining either whether a crisis will happen or when it will happen. Whether and when a crisis happens depend only on the position of the vertical ΔR curve in Fig. 1 – which determines the rate of reserve depletion – as well as on the lower bound that applies to the stock of reserves. The autonomous component of the balance of payments, as we have seen, determines only the value of *K*. What this means is that factors such as the size of the trade deficit, the stock of external debt, the maturity composition of that debt, and the cost of external borrowing, play no role in determining whether and when a crisis occurs. Second, a "first generation" crisis need not entail a "sudden stop" of capital inflows. Krugman's (1979) contribution was to show that at the time of the regime switch associated with the crisis, M^D would fall, triggering a speculative attack. From that point on, the balance of payments would be zero, with the rate of hoarding by domestic residents equal to the exogenously-determined rate of domestic credit expansion under the floating rate regime. But the balance of payments identity (1) would obviously continue to hold during the regime transition as well as subsequently, and its role in the model remains the same before, during, and after the transition: to determine *K* for given values of ΔR_A and *F*. Specifically, the model is not inconsistent with an exogenously-determined value of F before, during, and after the transition. Finally, notice that there is nothing in this simple model that suggests any disruption of real economic activity.

Now suppose that $\Delta DC = M^D - M_0$, so $EDM = \Delta R = 0$, so that a first generation crisis can be ruled out. In this setting, consider how the functioning of this economy would be affected by an outbreak of panic.

2 Country Panics

In heuristic terms, we can define a "country panic" as a situation in which the widespread expectation emerges among (both foreign and domestic) holders of claims on the domestic economy that the value of these claims will become impaired, just as happens among actual and potential depositors in the context of a bank panic. As a result of the emergence of such an expectation in a traditional bank panic, existing depositors pull their money out of banks and no new depositors appear to put any new money in.

By analogy with the "no new depositors" part of this characterization, I will assume that under a country panic:

i. Foreign creditors refuse to provide new loans ($F_P = 0$)
ii. Domestic residents do not repatriate capital ($K_P \geq 0$),

where F_P and K_P are the "panic" values of F and K respectively. A panic thus implies a "sudden stop" of capital inflows (Calvo 1998).[3] But notice that the sudden stop phenomenon does not determine the capital account of the balance of payments in the country undergoing a panic. Specifically, it does not pin down the effects of the panic on the magnitude of capital outflows by domestic residents (K).[4] As defined above, the "sudden stop" component of the panic simply rules out capital repatriation by domestic residents.

It is clear from (4) (with F set equal to zero) that the magnitude of capital outflows by domestic residents must be directly associated with changes in the domestic demand for money, other things (i.e., the stance of monetary policy in the form of ΔDC) being equal. Thus, to determine the effects of the panic on K we can either model its effects on M^D and infer its effects on K from (4), or model its effects on K and use (4) to infer its effect on M^D.

In a more complete model, we would expect domestic residents to determine M^D by trading off the higher return that they could expect from holding foreign rather than domestic assets in the event of a panic against the transactions benefits derived by holding domestic money. The "panic" value of K could then be inferred from the resulting solution for M^D and Eq. (4). However, it is far simpler in the present context to follow the route of telling a plausible story about K and then inferring from it the implied behavior of M^D.

[3] As shown below, however, the association of sudden stops with panics does not imply that the sudden stop is arbitrary or irrational.

[4] We can refer to this by the traditional term of capital flight. It is the component of the country panic that is analogous to the withdrawal of deposits during a bank panic. Rothenberg and Warnock (2006) emphasize the need to take the behavior of current residents into account in the analysis of sudden stops.

Concretely, in the event of a panic we will write K as:

$$\begin{aligned} K_P &= \Delta R_A + ESM/s = K_N - F = if\ \Delta R_A + ESM/s > 0. \\ &= 0\ otherwise. \end{aligned} \tag{5}$$

The assumption, therefore, is that if the flow demand for money by domestic residents is small enough during normal times so that domestic residents would have been moving money overseas during such times – even in the absence of new lending by foreigners – their demand for money is unchanged by the panic. In that case, domestic residents undertake capital outflows in the context of a panic, but these outflows are actually *smaller* than they would be in normal times, because the cessation of new lending by foreigners requires domestic residents to curtail their capital outflows in order to satisfy their unchanged demand for money. On the other hand, if domestic residents' "normal" flow demand for money is sufficiently large that satisfying that demand would actually require them to repatriate capital during panic times when new lending by foreigners disappears, then they are simply assumed to reduce their demand for domestic money during panic times by precisely the amount required to avoid capital repatriation under such circumstances.[5]

3 Are Rational Panics Possible?

We now have all of the components of a very simple model of sudden stops. The question we need to address in the context of this model is whether a "country panic" can be a rational expectations equilibrium. That is the issue to be investigated in this section. In the case of the Asian crisis, the Achilles heel of the East Asian countries was in the financial and real sectors, in the form of currency (not maturity) mismatches in the balance sheets of firms and banks, combined with high leverage among firms and weak capital bases among banks. This situation meant that if the exchange rate depreciated excessively, firms and banks would tend to become insolvent. This section will develop a simple model that explores the conditions under which this type of vulnerability could generate a rational panic.

To capture in a simple way the vulnerability of firms and banks to currency mismatches, suppose that there is some threshold value of the exchange rate, say s^*, beyond which currency mismatches, high leverage and weak capital bases create widespread solvency crises among domestic agents. That is, suppose there is some value s^* such that if $s > s^*$ domestic agents effectively become insolvent – i.e., they are unable to service their debts on market terms. Since creditors will be justified in their fears that their claims will not be honored if and only if $s > s^*$, a panic will turn out to be rational in this context if in the event of a panic $s > s^*$, but not otherwise. To know whether a panic can be rational, therefore, we have to answer two questions:

- Will the central bank be able to defend the exchange rate in the event of a panic?
- If not, how far will the exchange rate move?

[5] Alternatively, suppose there is a lower bound to domestic residents' end-of-period demand for money given, say by $\underline{M}^D$. This could be the result, say, of a convex transactions cost function. Then we could define a panic as a situation in which $F=0$ and M^D is driven down to $\underline{M}^D$. The workings of the model would be similar in this case to that in the text, except that capital outflows by domestic residents would be larger.

To address these questions, suppose for concreteness that the panic is binding on domestic private agents, in the sense that:

$$\begin{aligned} K_P &= \Delta R_A - EDM = K_N - F \text{ } if \text{ } \Delta R_A - EDM > 0. \\ &= 0 \text{ } otherwise. \end{aligned}$$

That is, the domestic demand for money is sufficiently large that in the absence of the panic the private sector would have repatriated capital. Then, in the event of a panic, the balance of payments is given by:

$$\begin{aligned} \Delta R_P &= \Delta R_A + F_P - K_P \\ &= \Delta R_A \end{aligned}$$

Since the sudden stop phenomenon means that the central bank will be unable to borrow in the event of a panic, it will be able to sustain the prevailing exchange rate only if its initial stock of reserves is greater than the maximum loss of reserves it would sustain at the official exchange rate if a panic breaks out. It follows that a sufficient condition for the central bank to be able to sustain the exchange rate is:

$$-R_0 \leq \Delta R_A$$

If this condition is met, and if the central bank is indeed willing to commit all of its reserves to defending the official exchange rate, then a panic cannot be a rational expectations equilibrium, because the model does not contain a mechanism for actual experience to be consistent with creditors' expectations of default. We conclude that a necessary condition for a rational panic is:

$$-R_0 > \Delta R_A. \tag{6}$$

The implication is that a country can protect itself from rational panics by maintaining a sufficiently large stock of reserves.[6]

When, then, could a rational panic happen? Notice first that (6) is only a *sufficient*, but not a *necessary* condition to preclude a rational panic. That is, it is possible that the central bank would *not* be able to defend the exchange rate, so that (6) would not hold, yet a panic would nevertheless not be a rational expectations equilibrium. This would happen if the abandonment of the prevailing parity resulted in a new equilibrium exchange rate with $s < s^*$. Thus a panic can be a rational expectations equilibrium in the context of this model only if in the event of a panic, the exchange rate is forced to depreciate to the point where $s > s^*$. Under what conditions would this happen?

To determine the equilibrium value of the exchange rate in the event of a panic, note that since a country's links with world capital markets are severed in this case, its

[6] Notice what this means: if a rational panic is possible, then the resulting equilibrium will share an important feature with "first generation" currency crisis models – i.e., the central bank will experience a "speculative attack" in the form of a sudden stop of capital inflows (and possibly of capital outflows by domestic agents) – that will deplete its stock of foreign exchange reserves and thus force it to abandon the officially-determined exchange rate. As we will see below, however, the outcome differs from that in first-generation currency crisis models in that the attack is neither inevitable nor can its timing be foreseen.

exchange rate must be determined in "flow" markets by the balance of payments equilibrium condition:

$$-R_0 = \Delta R_A = B(\theta, s) - (i * +\gamma) D_0, \tag{7}$$

where the assumption is that the central bank sells its entire existing stock of reserves R_0 in the foreign exchange market. Thus, the critical value of reserves that the central bank would have to sell to ensure that the floating exchange rate does not surpass s^* is implicitly given by:

$$-R^* = B(\theta, s^*) - (i^* + \gamma) D \tag{8}$$

The determination of R^* can be shown graphically as follows. Going back to Fig. 1, notice that if in "normal" times $F - K_N > 0$ – that is, if the country was experiencing a capital account surplus (excluding amortization payments) – then the outbreak of a panic, which would drive the value of $F - K$ to zero or make it negative, would cause the BP curve to shift leftward, to a position such as BP' in Fig. 2. The locus BP' can be used to determine the volume of reserve sales required to sustain any given exchange rate in the event of a panic (by finding the value of R that corresponds to any given value of s along BP') or the post-panic equilibrium value of the exchange rate for any given volume of reserve sales by the central bank (by finding the value of s that corresponds to any given value of R along BP'). It is easy to see, then, that the critical value R^* is determined by the point at which a horizontal line at height s^* intersects the curve BP', since if the central bank sells reserves in the amount R^* the equilibrium exchange rate would indeed be s^*.

Now let R_0 denote the maximum stock of reserves that the central bank is able (willing?) to sell, as before. Then, if $R_0 > R^*$, no rational panic is possible, because the central bank would be willing and able to sell enough reserves as to sustain the exchange rate at a level that is more appreciated than its critical value s^*. But if $R_0 < R^*$, then the economy moves into a multiple-equilibrium situation, as at point C in Fig. 2. With reserve stock R_0, if a panic arises the equilibrium exchange rate would jump from s_0 to s_P. Since $s_P > s^*$, *ex post* the panic will have been rational, because the

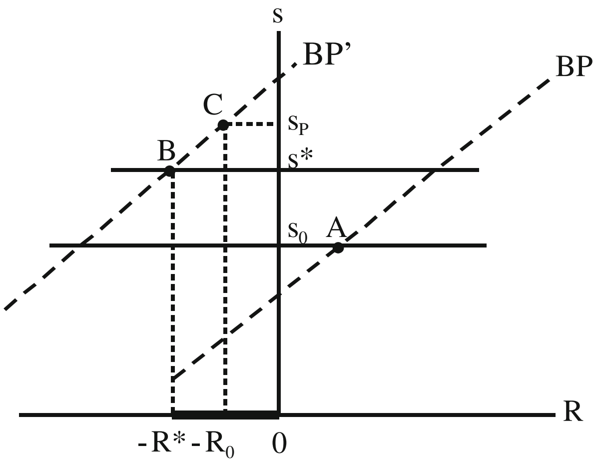

Fig. 2 Balance of payments equilibrium in a rational panic

severe depreciation of the currency means that domestic agents will become insolvent, justifying the refusal by (foreign and domestic) creditors to acquire new claims on domestic agents. If a panic does not arise, however, then the economy's equilibrium will remain at the point A, on the original BP curve. In that case domestic agents' debt will be serviced on market terms and the official exchange rate will be sustained.

The upshot is that there is a zone of vulnerability, in the range $R < R^*$ (indicated by the heavily shaded portion of the horizontal axis in Fig. 2), within which the economy is characterized by multiple equilibria. In this zone, macroeconomic outcomes will be determined by creditors' expectations: if they expect to be repaid on contractual terms they will sustain capital inflows, the official exchange rate will be sustained, and creditors' expectations of repayment will indeed be borne out. But if they do not expect to be repaid, then their reaction in the form of a "sudden stop" of capital inflows will trigger a depreciation of the exchange rate that renders debtors insolvent, ensuring that they indeed are not repaid, and justifying their panic.

While the framework for crisis modeling just described is extremely simple, it has several interesting properties:

- In this framework, crises can happen even if all of the usual "solvency" fundamentals (investment, saving, growth, fiscal deficits) in the affected country look satisfactory. The reason is, of course, that the crisis described in the model is a *liquidity* crisis. In this model, the insolvency of domestic debtors is brought about by the creditor panic, rather than vice versa.
- Recall that in the simplest "first-generation" model, the magnitude of the country's trade deficit, the magnitude of its external debt, its debt-servicing costs, and the maturity composition of the debt affect neither the probability of a crisis nor its timing. As we shall explore in more detail below, in the present context all of these factors affect the country's vulnerability to a liquidity crisis.
- Neither fundamentals nor panic are individually sufficient to cause a crisis in this setup. Panic (in the form of $F = K = 0$ and the resulting elimination of the central bank's foreign exchange reserves) will not result in crisis if $R > R^*$, and weak fundamentals (in the form of $R < R^*$) will not generate a crisis in the absence of a panic.
- The situation in this model is characterized by mutiple equilibria. A panic *can* happen if $R_0 < R^*$, but it need not. Both outcomes are rational. Thus, a severe crisis can hit a country even when it has not undergone any perceptible change in fundamentals. This can happen if random events trigger a panic when $R < R^*$.
- Finally, in this context contagion can arise easily through "wake-up call" or "heightened awareness" effects in countries with $R < R^*$.

4 Determinants of Vulnerability

It is obvious that the equilibria at A and C are quite different. In particular, the widespread insolvencies at the point C are likely to be associated with severe disruptions of productive activity and a sharp contraction of domestic output. The question for policymakers thus becomes how the zone of vulnerability that could result in equilibria such as C, determined by R^*, can be avoided.

4.1 The Role of Reserves

One immediate answer to this question is that vulnerability can be avoided by simply holding a sufficiently large stock of reserves. Given R^*, what is required is simply that the authorities' stock of reserves satisfy $R > R^*$. In particular, the model suggests that countries can protect themselves from vulnerability to adverse equilibria such as C by holding a sufficient stock of foreign exchange reserves. It also suggests that the amount of protection that they require, and thus the stock of reserves that they would need to hold, depends on the value of R^* – i.e., on the size of each country's zone of vulnerability. Thus, one would expect R^* to be an important determinant of the demand for reserves by emerging market economies. This has two interesting implications.

First, it suggests that simple indicators of reserve adequacy, such as the traditional ratio of reserves to imports, or other ratios that have recently come into vogue – such as the ratio of reserves to base money or to the stock of short-term external debt – are likely to be of limited usefulness as indicators of vulnerability. What matters is the ratio R/R^*, and as we will see below, R^* is poorly proxied by the monetary base or the stock of short-term debt.

Second, it provides an interpretation for the reserve accumulation behavior of several emerging-market economies in the wake of the Asian crisis. In particular, it suggests that the massive amounts of reserves that many such countries have accumulated after the 1997–98 crisis is indicative of those countries' perception that their zones of vulnerability remain relatively large.

4.2 The Size of the Zone of Vulnerability

It is easy to verify by inspection of Fig. 2 that the zone of vulnerability within which multiple equilibria are possible depends on three factors: it will be larger the more appreciated the threshold exchange rate s^*, the larger the vertical intercept of the BP' curve, and the shallower the slope of this curve. Thus, we can examine the determination of R^* by considering each of these factors in turn.

4.2.1 Determinants of s^*

Recall that s^* is the threshold value of the exchange rate beyond which domestic debtors default. The value of the exchange rate required to wipe out the net worth of any given agent depends on the size of that agent's foreign currency liabilities relative to its foreign currency assets as well as on the agent's net worth. The former determines the agent's exposure to currency risk, and the latter the size of the cushion that the agent has available to offset unexpected losses arising from adverse exchange rate movements.

Based on what has already been said, it is easy to see that the threshold value s^* will in general depend on the health of the balance sheets of domestic nonfinancial firms and financial institutions. In particular, it should depend on the extent of mismatches in the balance sheets of domestic firms and financial intermediaries, as well as on the leverage ratios of nonfinancial firms and the capital adequacy of banks. The more closely matched are foreign currency liabilities with foreign currency assets in the balance sheets of domestic agents, the lower the leverage ratio among domestic nonfinancial firms, and the larger the capital bases of domestic financial institutions, the larger s^* would tend to be. At a deeper level, then, s^* would in general be expected to depend on the quality of domestic institutions – specifically, those institutions affecting the quality of corporate governance as well as of the domestic financial regulatory environment.

Moral hazard plays a role in this model through its effects on s^*. To the extent that perceptions of exchange rate risk create a wedge between the interest rates on domestic-currency assets and those on foreign-currency assets, weaknesses in the domestic institutional environment that give free play to moral hazard encourage domestic firms and banks to pursue the high-risk strategy of borrowing at low interest rates in foreign currency, even if they lack the offsetting foreign-currency denominated assets that would protect them from exchange rate risk. This creates the currency mismatches that give rise to a low value of s^*.

4.2.2 Determinants of the Position of the BP' Curve

Other things the same, the zone of vulnerability will be larger the larger the vertical intercept of the BP' curve. This depends, in turn, on the value of the trade deficit that prevails at the official exchange rate ($-B$), on the country's gross stock of external debt D, on its external borrowing costs i^*, and on the maturity of its external debt (indexed by γ). A large initial trade deficit, large stock of external debt, large "supply price" of external funds, and short debt maturity all cause the BP' curve to intersect the vertical axis at a relatively depreciated value of the exchange rate, thus magnifying the size of the zone of vulnerability. The reason is, of course, that all of these factors contribute to a large *flow* demand for foreign exchange, thus requiring a relatively depreciated exchange rate in order to clear the "autonomous" component of the balance of payments.

Notice that the magnitude of external debt D matters in this model only because it influences debt servicing costs $(i^* + \gamma)D$, a flow variable. Thus this model creates a link between "capital market crises" (Calvo 1996) and the standard flow variables emphasized in traditional analyses of current account sustainability. The link emerges through the "transfer problem" (Krugman 1999) – the effects of large *ex ante* flow disequilibria in the balance of payments on the value of the exchange rate required to clear the balance of payments in the face of a sudden stop in capital inflows. It is precisely the interaction of a severe "transfer problem" in the flow balance of payments and currency mismatches in domestic balance sheets that makes rational panics possible in this model.

4.2.3 Determinants of the Slope of the BP' Curve

The final elements determining the size of the zone of vulnerability are the factors underlying the slope of the BP' curve. These involve elasticities of substitution in domestic supply and demand for traded goods, as well as the size of the domestic traded goods sector. The larger the elasticities of supply and demand, as well as the larger the domestic traded goods sector, the flatter the BP curve will be, because each of these factors will tend to magnify the effects of exchange rate changes on the trade balance.

It is easy to see from Fig. 2 that the size of the zone of vulnerability will be *smaller* the flatter is the BP' curve. To see why, note that the outbreak of a panic will cause the BP curve to the shift to left, moving its intersection with a horizontal line through the official exchange rate s_0 from the initial "normal times" equilibrium at A to a point such as D. From D, the intersection of the BP' curve with a horizontal line through $s*$, which determines the size of the zone of vulnerability, will be closer to the vertical axis (thereby making the zone of vulnerability *smaller)* the flatter the BP' curve is. The intuition is, of course, that when the BP curve is flat the trade balance is highly sensitive to exchange rate movements, so the change in the exchange rate required to maintain balance of payments equilibrium in the face of a sudden stop will tend to be smaller under such circumstances, making it less likely that the depreciation in the exchange rate will breach the $s*$ threshold.

Because very open economies producing traded goods that do not rely on highly specialized factors of production are likely to have relatively flat BP curves, it follows that such economies are less likely to be vulnerable to rational panics, other things being equal.[7]Because these conditions tended to characterize the economies that were most severely affected by the Asian financial crisis, the suggestion of the model is that such economies became vulnerable only when their currency mismatch problems and/or flow disequilibria in their balance of payments became sufficiently severe.

5 Summary and Conclusions

The model developed in this paper is stylized and simple. Nevertheless, it both incorporates a number of features that have been considered important in more sophisticated explanations of the sudden stop phenomenon and provides several useful insights of its own. The latter can be divided into two types: insights of a general nature about the characteristics of currency crises and more specific insights about what might (in hindsight) have been done to avert crises characterized by sudden stops, such as those in Asia. To conclude the paper, I take these up in turn.

The model developed in this paper suggests that currency crises may be highly nonlinear events, in these sense that they emerge as the result of interactions among several factors, all of which have to be present in sufficient force to create the *possibility* of (i.e., vulnerability to) a crisis. The model demonstrates, for example, that large flow disequilibria in the balance of payments, which can themselves arise from a variety of sources, need not be associated with crises unless the "threshold" exchange rate $s*$ is sufficiently low, the trade balance is sufficiently inelastic with respect to exchange rate changes, and the reserve stock is sufficiently low. But even when these

[7] Calvo et al. (2004), as well as Edwards (2004) provide empirical evidence that openness tends to mitigate the adverse output effects of "sudden stops." In the model of this paper, the explanation for this result is that openness tends to mitigate the real exchange rate adjustment associated with a sudden stop, and thus reduce the macroeconomic dislocations associated with real depreciation in the presence of currency mismatches.

factors interact to create a non-vanishing zone of vulnerability, a crisis need not ensue in the absence of a shock that triggers a creditor panic. It is hardly surprising, then, that the large empirical literature that has emerged over the past decade exploring the factors that tend to predict currency crises has found it so difficult to explain the incidence of crises or to identify a robust set of crisis determinants.

What, then, does the model suggest about how crises such as those in Asia could have been avoided? The key objective would have been to avoid the zone of vulnerability. A wide range of policies could have achieved this result, including structural policies, monetary and fiscal policies, policies directed at the capital account of the balance of payments, and exchange rate policy.

- Structural policies

  Policies directed at the financial sector could have contributed to the avoidance of vulnerability by increasing s^*. This refers specifically to regulatory and supervisory policies that require financial institutions to maintain an adequate capital base and to avoid currency mismatches.
- Macroeconomic policies

  Monetary and fiscal policies intended to restrain the growth of aggregate demand can be captured in the model through an increase in the parameter θ. The effect of an increase in θ is to reduce the country's trade deficit. Such an adjustment in θ would have reduced vulnerability by shifting the BP' curve downward. It is worth noting that an *ex ante* policy rule of increasing θ *in response* to the emergence of a panic can in principle be sufficient to avoid the panic altogether by eliminating the zone of vulnerability, if the planned adjustment in θ is of sufficient magnitude and if the announced policy rule can be made credible. A separate issue concerns an *ex post* increase in θ once a panic has broken out. The effect of such an increase would be to shift some of the burden of adjustment in the balance of payments from the exchange rate to θ, thus reducing the required magnitude of exchange rate depreciation and minimizing the macroeconomic dislocations arising from insolvencies triggered by exchange rate depreciation in the context of currency mismatches. This was precisely the rationale used by the IMF in initially supporting fiscal tightening in the Asian crisis countries that adopted IMF-supported programs.
- Capital account policies

  A given adjustment in aggregate demand (and thus increase in θ) can be achieved with alternative fiscal-monetary mixes, however. Some empirical evidence (see Montiel and Reinhart 1999) supports the view that a combination of loose fiscal policies and tight monetary policies may be associated with a shortening of the maturity of capital inflows. Thus the nature of the fiscal-monetary mix is one element of the policy regime that may affect the maturity composition of a country's external debt. Others may include the extent of nominal exchange rate variability,[8] as well as specific capital-account restrictions[9] that are intended to affect the maturity composition of external debt. If deployed before the crisis,

[8] In the context of the "soft" pegs maintained by the Asian crisis countries before the crisis, this would refer to the width of their exchange rate bands.

[9] These include measures such as the Chilean *encaje*, as well as specific prudential regulations on external borrowing by domestic agents.

some combination of these capital account policies could have had the effect of lowering γ, thus shifting the BP' curve downward and shrinking the zone of vulberability.

- Exchange rate policies

  All of the policies listed above would have reduced the likelihood of crisis by shrinking the size of the zone of vulnerability. Given the size of that zone, however, victims of sudden stops could have reduced their vulnerability to crisis by maintaining a sufficiently large stock of liquidity so as to render the defense of their official parities credible even in the event of a panic-driven "sudden stop." Put differently, if faced with the progressive depletion of reserves (as in the case of Thailand during 1996-97), they would have been well advised to free the exchange rate before reserves reached the critical value $R = R^*$.

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