ex ante as less integrated with world capital markets than industrial countries. The same methodology, with similar results, was used by Wong (1990) to look at a cross-section sample of forty five developing countries. Khalkhali and Dara (2007) applied a varying coefficients error-correction approach to twenty three industrial countries over the period 1970–2003 and found evidence of a close relationship between saving and investment, both in the short and the long run, with the long-run relationship appearing to be stronger for the more open economies. By contrast, they found no evidence that countries that are more open to trade are also more open in terms of capital flows, that is, the degree of capital mobility does not appear to be positively related to trade openness. Finally, in a study of Mexico's experience during the period 1960–2002, Payne (2005) found that savings and investment are cointegrated (suggesting low capital mobility in the long run), but there is also evidence of structural instability following the debt crisis that the country experienced in the early 1980s.

Overall, the existing evidence for developing countries suggests that few, if any, developing countries can be considered to be financially closed. At the same time, while many of these countries should be regarded as financially open, perfect capital mobility does not hold.

15

Exchange-Rate Crises

The sources and implications of inconsistencies that may arise between the exchange-rate regime and other macroeconomic policy instruments have been the subject of considerable attention in recent years. The currency crises that have occurred since the early 1990s (particularly in Mexico, as discussed below) have led to a resurgence of interest in models of speculative attacks and exchange-rate crises. Two strands appear to dominate the literature at present. "Conventional" models tend to emphasize inconsistencies between fiscal, monetary, and exchange-rate policies and the role of speculative attacks in "forcing" the abandonment of a currency peg.

More recent models, by contrast, emphasize the vulnerability of exchange-rate systems even in the presence of consistent macroeconomic policies and sound market fundamentals. They explicitly account for policymakers' preferences and the trade-offs that they face in their policy objectives. In this setting, an exchange-rate "crisis" (a devaluation or a switch to a floating-rate regime) is viewed as an ex ante optimal decision for the policymaker. These models also highlight the role of self-fulfilling mechanisms, multiple equilibria, and credibility factors. For instance, an arbitrary increase in inflation expectations (induced by a perceived incentive to relax monetary and fiscal policies in the face of persistent unemployment) may raise domestic interest rates to such an extent that the cost of preserving the peg (foregoing the possibility to stimulate output by raising prices and lowering real wages) becomes so large that the authorities may find it optimal to devalue or abandon altogether a fixed exchange-rate regime. Market expectations may thus take on the characteristics of self-fulfilling prophecies. Another line of reasoning, which has led to the so-called third-generation models of currency crises, emphasize the role of balance sheet factors and financial sector weaknesses in triggering speculative attacks.

This chapter is organized in five parts. The first part discusses how macroeconomic policy inconsistencies may lead to recurrent speculative attacks and ultimately to the collapse of a fixed exchange rate. The second part examines the second-generation models of currency crises. It begins by considering a simple model that illustrates the interactions between policymakers' preferences (in the presence of an inflation–unemployment trade-off) and self-fulfilling expectations. It then considers the links between credibility and reputation (as discussed in Chapter 12) and the decision to devalue. The third part discusses briefly recent attempts to integrate first- and second-generation models of currency crises. The fourth part examines third-generation models

of currency crises. The fifth part reviews experiences with currency crises in Mexico, Thailand, Brazil, and Argentina.[1]

1 | Currency Crises: Conventional Approach

A fundamental proposition of open-economy macroeconomics is that the viability of a fixed exchange-rate regime requires maintaining long-run consistency between monetary, fiscal, and exchange-rate policies. "Excessive" domestic credit growth leads to a gradual loss of foreign reserves and ultimately to an abandonment of the fixed exchange rate, once the central bank becomes incapable of defending the parity any longer. Over the past decade a large formal literature has focused on the short- and long-run consequences of incompatible macroeconomic policies for the balance of payments of a small open economy in which agents are able to anticipate future decisions by policymakers. In a pioneering paper, Krugman (1979) showed that under a fixed exchange-rate regime, domestic credit creation in excess of money demand growth may lead to a sudden speculative attack against the currency that forces the abandonment of the fixed exchange rate and the adoption of a flexible-rate regime. Moreover, this attack will always occur *before* the central bank would have run out of reserves in the absence of speculation, and will take place at a well-defined date.

This section examines the implications of the literature on balance-of-payments crises for understanding the collapse of exchange-rate regimes in developing countries.[2] We first set out a single-good, full-employment, small open-economy model that specifies the basic theoretical framework used for analyzing balance-of-payments crises. We then summarize some important extensions of this framework, namely, the nature of the post-collapse exchange-rate regime, the output and current account implications of an anticipated exchange-rate crisis, and the role of external borrowing and capital controls.

1.1 | The Basic Model

Consider a small open economy whose residents consume a single, tradable good. Domestic supply of the good is exogenous, and its foreign-currency price is fixed (at, say, unity). The domestic price level is equal, as a result of purchasing-power parity, to the nominal exchange rate. Agents hold three categories of assets: domestic money (which is not held abroad), and domestic

[1] Although our focus in this chapter is on crises, it should be noted that a number of countries managed to exit pegged exchange-rate regimes in an orderly manner; see Agénor (2004*a*) and Asici et al. (2005) for a discussion and some formal empirical evidence on the conditions for a successful exit.

[2] This section draws to a large extent on Agénor and Flood (1994).

and foreign bonds, which are perfectly substitutable. There are no private banks, so that the money stock is equal to the sum of domestic credit issued by the central bank and the domestic-currency value of foreign reserves held by the central bank. Foreign reserves earn no interest, and domestic credit expands at a constant nominal growth rate. Finally, agents are endowed with perfect foresight.

The model is defined by the following set of equations:

$$m - p = y - \alpha i, \quad \alpha > 0, \tag{1}$$

$$m = \gamma d + (1-\gamma)R, \quad 0 < \gamma < 1, \tag{2}$$

$$\dot{d} = \mu > 0, \tag{3}$$

$$p = e, \tag{4}$$

$$i = i^* + \dot{e}. \tag{5}$$

All variables, except interest rates, are measured in logarithms. m denotes the nominal money stock, d domestic credit, R the domestic-currency value of foreign reserves held by the central bank, e the spot exchange rate, p the price level, y exogenous output, i^* the foreign interest rate (assumed constant), and i the domestic interest rate.

Equation (1) relates the real demand for money positively to real income and negatively to the domestic interest rate. Equation (2) is a log-linear approximation to the identity defining the money stock as the stock of reserves and domestic credit, which grows at the nominal rate μ (Equation 3). Equations (4) and (5) define, respectively, purchasing-power parity and uncovered interest parity.

Setting $\delta = y - \alpha i^*$ and combining Equations (1), (4), and (5) yields

$$m - e = \delta - \alpha \dot{e}, \quad \delta > 0. \tag{6}$$

Under a fixed exchange-rate regime, $\bar{e}$ and $\dot{e} = 0$, so that

$$m - \bar{e} = \delta, \tag{7}$$

which indicates that the central bank accommodates any change in domestic money demand through the purchase or sale of foreign reserves to the public.[3] Using Equations (2) and (7) yields

$$R = (\delta + \bar{e} - \gamma d)/(1-\gamma), \tag{8}$$

[3] Becuse capital is perfectly mobile, the stock of foreign reserves can jump discontinuously as private agents readjust their portfolios in response to current or anticipated shocks.

and, using (3),

$$\dot{R} = -\mu/\Theta, \quad \Theta \equiv (1-\gamma)/\gamma. \tag{9}$$

Equation (9) indicates that if domestic credit expansion is excessive [that is, if it exceeds the rate of growth of the demand for money, which depends on δ as shown in Equation (7), and is assumed here to be zero], reserves are run down at a rate proportional to the rate of credit expansion. Any finite stock of foreign reserves will therefore be depleted in a finite period of time.

Suppose that the central bank announces at time t that it will stop defending the current fixed exchange rate after reserves reach a lower bound, R_l, at which point it will withdraw from the foreign exchange market and allow the exchange rate to float freely thereafter. With a positive rate of domestic credit growth, rational agents will anticipate that, without speculation, reserves will eventually fall to the lower bound, and will therefore foresee the ultimate collapse of the system. To avoid losses arising from an abrupt depreciation of the exchange rate at the time of collapse, speculators will force a crisis *before* the lower bound on reserves is reached. The issue is thus to determine the exact moment at which the fixed exchange-rate regime is abandoned or, equivalently, the time of transition to a floating-rate regime.

The length of the transition period can be calculated by using a process of backward induction, which has been formalized by Flood and Garber (1984). In equilibrium and under perfect foresight, agents can never expect a discrete jump in the level of the exchange rate, because a jump would provide them with profitable arbitrage opportunities. As a consequence, arbitrage in the foreign exchange market requires the exchange rate that prevails immediately after the attack to equal the fixed rate prevailing at the time of the attack. Formally, the time of collapse is found at the point where the "shadow floating rate," which reflects market fundamentals, is equal to the prevailing fixed rate. The shadow floating rate is the exchange rate that would prevail with the current credit stock if reserves had fallen to the minimum level and the exchange rate were allowed to float freely. As long as the fixed exchange rate is more depreciated than the shadow floating rate, the fixed-rate regime is viable; beyond that point, the fixed rate is not sustainable. The reason is that if the shadow floating rate falls below the prevailing fixed rate, speculators would not profit from driving the government's stock of reserves to its lower bound and precipitating the adoption of a floating-rate regime, because they would experience an instantaneous capital loss on their purchases of foreign currency. On the other hand, if the shadow floating rate is above the fixed rate, speculators would experience an instantaneous capital gain. Neither anticipated capital gains nor losses at an infinite rate are compatible with a perfect-foresight equilibrium. Speculators will compete with each other to eliminate such opportunities. This type of behavior leads to an equilibrium attack, which incorporates the arbitrage condition that the pre-attack fixed rate should equal the post-attack floating rate.

A first step, therefore, is to find the solution for the shadow floating exchange rate, which can be written as

$$e = \kappa_0 + \kappa_1 m, \tag{10}$$

where κ_0 and κ_1 are as-yet-undetermined coefficients and, from (2), $m = \gamma d + (1-\gamma)R_l$ when reserves reach their lower level.[4]

Taking the rate of change of Equation (10) and noting from Equation (2) that under a floating-rate regime $\dot{m} = \gamma \dot{d}$ yields

$$\dot{e} = \kappa_1 \gamma \mu. \tag{11}$$

In the post-collapse regime, therefore, the exchange rate depreciates steadily and proportionally to the rate of growth of domestic credit. Substituting (11) in (6) yields, with $\delta = 0$ for simplicity,

$$e = m + \alpha \kappa_1 \gamma \mu. \tag{12}$$

Comparing Equations (12) and (10) yields

$$\kappa_0 = \alpha \gamma \mu, \quad \kappa_1 = 1.$$

From Equation (3), $d = d_0 + \mu t$. Using the definition of m given above and substituting in Equation (12) yields

$$e = \gamma(d_0 + \alpha\mu) + (1-\gamma)R_l + \gamma\mu t. \tag{13}$$

The fixed exchange-rate regime collapses when the prevailing parity, $\bar{e}$, equals the shadow floating rate, e. From (13) the exact time of collapse, t_c, is obtained by setting $\bar{e} = e$, so that

$$t_c = [\bar{e} - \gamma d_0 - (1-\gamma)R_l]/\gamma\mu - \alpha,$$

or, because, from Equations (2) and (7), $\bar{e} = \gamma d_0 + (1-\gamma)R_0$,

$$t_c = \Theta(R_0 - R_l)/\mu - \alpha, \tag{14}$$

where R_0 denotes the initial stock of reserves.

[4] In general, the exchange-rate solution can be derived—assuming no bubbles—by using the forward expansion of Equation (6) and the definition of m when reserves reach their minimum level:

$$e = (\gamma/\alpha)\int_t^\infty [d_h + (1-\gamma)R_l - \delta]\exp[(t-h)/\alpha]dh,$$

or by using Equation (3),

$$e = (\gamma/\alpha)\int_t^\infty [d + (k-t)\mu + (1-\gamma)R_l - \delta]\exp[(t-h)/\alpha]dh,$$

which expresses the shadow floating exchange rate as the "present discounted value" of future fundamentals. Integrating this expression by parts yields Equation (13) below.

Equation (14) indicates that the higher the initial stock of reserves, the lower the critical level, or the lower the rate of credit expansion, the longer it will take before the collapse occurs. With no "speculative" demand for money, $\alpha = 0$, and the collapse occurs when reserves are run down to the minimum level. The interest rate (semi-) elasticity of money demand determines the size of the downward shift in money balances and reserves that takes place when the fixed exchange-rate regime collapses and the nominal interest rate jumps to reflect an expected depreciation of the domestic currency. The larger α is, the earlier the crisis.[5]

The analysis implies, therefore, that the speculative attack always occurs before the central bank would have reached the minimum level of reserves in the absence of speculation. Using Equation (8) with $\delta = 0$ yields the stock of reserves just before the attack (that is, at t_c^-):[6]

$$R_{t_c^-} \equiv \lim_{t \to t_c^-} R_{t_c} = (\bar{e} - \gamma d_{t_c^-})/(1-\gamma),$$

where $d_{t_c^-} = d_0 + \mu t_c^-$, so that

$$R_{t_c^-} = [\bar{e} - \gamma(d_0 + \mu t_c^-)]/(1-\gamma). \tag{15}$$

Using Equation (14) yields

$$\bar{e} - \gamma d_0 = \gamma\mu(t_c^- + \alpha) + (1-\gamma)R_l. \tag{16}$$

Finally, combining (15) and (16) yields

$$R_{t_c^-} = R_l + \alpha\mu/\Theta. \tag{17}$$

Figure 15.1 illustrates the process of a balance-of-payments crisis, under the assumption that the minimum level of reserves is zero.[7]. The top panel of the figure portrays the behavior of reserves, domestic credit, and the money stock before and after the regime change, and the bottom panel displays the behavior of the exchange rate. Prior to the collapse at t_c, the money stock is constant, but its composition varies because domestic credit rises at the rate μ and reserves decline at the rate μ/Θ. An instant before the regime shift, a speculative attack occurs, and both reserves and the money stock fall by $\alpha\mu/\Theta$. Because $R_l = 0$, the money stock is equal to domestic credit in the post-collapse regime.

[5] Note also that the larger the initial proportion of domestic credit in the money stock (the higher γ), the sooner the collapse. γ, however, appears in our reduced form as an artifact of log-linearization, and is used in the model mainly to convert the exogenous credit growth rate to a money supply growth rate.

[6] R is discontinuous at time t_c. It is positive as approached from below and jumps down to its critical level R_l at t_c.

[7] Recall that R denotes the logarithm of the stock of foreign reserves, so it is simply an accounting convention to set $R_l = 0$

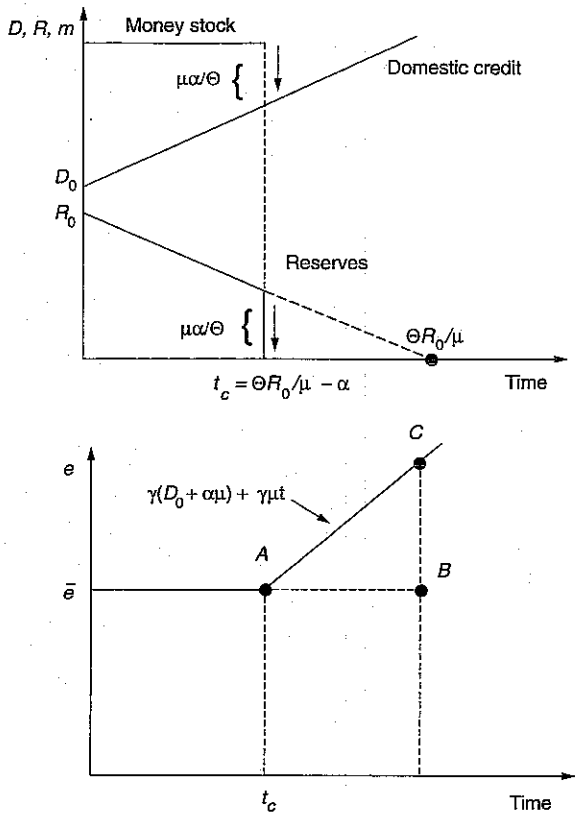

Figure 15.1
The Process of a Balance-of-Payments Crisis.
Source: Agénor and Flood (1994, p. 230.)

As shown in the bottom panel of Figure 15.1, the exchange rate remains constant at $\bar{e}$ until the collapse occurs. The path continuing through AB and then taking a discrete exchange-rate jump BC corresponds to the "natural collapse" scenario ($\alpha = 0$). With speculation, the transition occurs earlier, at A, preventing a discrete change in the exchange rate from occurring. Speculators, who foresee reserves running down to their critical level, avoid losses that would result from the discrete exchange-rate change by attacking the currency at the point where the transition to the float is smooth, that is, where the shadow floating exchange rate equals the prevailing fixed rate.[8]

[8] This analysis can be easily extended to consider the case where the precollapse regime is a crawling peg arrangement. See, for instance, Connolly and Taylor (1984).

1.2 | Extensions to the Basic Framework

The literature on balance-of-payments crises has refined and extended the basic theory presented above in a variety of directions. This subsection examines some of the areas in which this literature has developed. It first considers alternative assumptions regarding the post-collapse exchange-rate regime, focusing on the case of a (perfectly anticipated) temporary post-collapse period of floating followed by repegging. We then discuss the real effects of an exchange-rate collapse, and the role of foreign borrowing and the imposition of capital controls as policy measures aimed at postponing (or preventing) the occurrence of a balance-of-payments crisis.[9]

1.2.1 | Sterilization

A key assumption of the Krugman–Flood–Garber model is that the money supply falls, in line with money demand, at the moment the currency attack takes place. However, if reserve losses are completely sterilized, such a discrete jump will *not* take place. This case has been studied by Flood, et al. (1996). Their analysis shows that the fixed exchange-rate regime is not viable under full sterilization; as long as agents understand that the central bank plans to sterilize an eventual speculative attack, they will attack *immediately*. To see this, consider the money market equilibrium condition (6) with $\delta = 0$. If the money stock is constant as a result of sterilized intervention (at, say, $m = m_S$) and the exchange rate is fixed, this condition becomes

$$m_S - \bar{e} = 0,$$

whereas, in the post-attack floating-rate regime, with $\dot{e} = \mu$:

$$m_S - e = -\alpha\mu.$$

Subtracting the second expression from the first yields

$$e - \bar{e} = \alpha\mu > 0.$$

Thus, if the money supply does not change when the attack takes place, the shadow exchange rate (consistent with money market equilibrium) will always exceed the prevailing fixed exchange rate, thereby provoking an immediate attack. By adding a risk premium to the above model, Flood et al. (1996) show that the extended model with sterilization can be compatible with a fixed exchange rate. Essentially, the risk premium adjusts to keep the demand for money constant, just as sterilization maintains money supply constant. A feature of their analysis is that because the money supply does not change, and the exchange rate cannot jump (although its rate of change, $\dot{e}$, does),

[9] An area that has received much attention in recent years is the link between banking crises and exchange-rate crises. The analytical issues involved are examined in Chapter 16.

the domestic interest rate cannot jump either—in contrast to the standard framework.

1.2.2 | Alternative Post-Collapse Regimes

The focus of the early theoretical literature on balance-of-payments crises has been on the transition from a fixed exchange rate to a post-collapse floating rate. Various alternative scenarios are, however, suggested by actual experience. Following the breakdown of the fixed-rate system, the central bank can devalue the currency, implement a dual-exchange-rate arrangement, or adopt a crawling peg regime. In general, the timing of a crisis depends on the particular exchange-rate arrangement that agents expect the central bank to adopt after a run on its reserve stock has forced the abandonment of the initial fixed rate. We will examine, for illustrative purposes, the case in which, after allowing the currency to float for a certain period of time, the central bank returns to the foreign exchange market and fixes the exchange rate at a new, more depreciated level (Obstfeld, 1984).

Suppose that the length of the transitory period of floating, denoted by T, and the level $\bar{e}_H > \bar{e}$ to which the exchange rate will be pegged at the end of the transition are known with certainty.[10] The time t_c at which the speculative attack occurs is calculated, as before, by a process of backward induction. However, this principle now imposes two restrictions rather than one. First, as before, the initial fixed rate $\bar{e}$ must coincide with the relevant shadow floating rate, that is, $\bar{e} = e_{t_c}$. Second, at time $t_c + T$, the preannounced new fixed rate $\bar{e}_H$ must also coincide with the interim floating rate, $\bar{e}_H = e_{t_c+T}$.[11] The last requirement acts as a terminal condition on the exchange-rate differential equation.

In the foregoing discussion, when the central bank's policy was assumed to involve abandonment of the fixed rate and adoption of a permanent float thereafter, the shadow floating rate was given by Equation (12). Now, under a transitory floating regime, the shadow rate is given by

$$e = \kappa_0 + \kappa_1 m + C\exp(t/\alpha), \quad t_c \le t \le t_c + T \tag{18}$$

where C is an undetermined constant.[12] The complete solution must therefore specify values for both t_c and C. These values are obtained by imposing $\bar{e} = e_{t_c}$

[10] Note that the new fixed exchange rate, to be viable, must be greater than (that is, more depreciated) or equal to the rate that would have prevailed had there been a permanent post-crisis float.

[11] As before, this is implied by the absence of arbitrage profits, which rules out anticipated discrete changes in the exchange rate.

[12] The last term in Equation (18) represents a "speculative bubble" component, which was ruled out from the solution (13) by imposing the transversality condition $C = 0$. Imposing the terminal condition $\bar{e}_H = \bar{e}_{t_c+T}$ now requires $C \neq 0$.

and $\bar{e}_H = e_{t_c+T}$ on Equation (18).[13] The solutions for t_c and C are

$$t_c = (\bar{e} - \alpha\gamma\mu - \gamma d_0 - \Omega)/\gamma\mu, \tag{19}$$

$$C = \Omega \exp(-t_c/\alpha), \tag{20}$$

where $\Omega = [(\bar{e}_H - \bar{e}) - \gamma\mu T]/[\exp(T/\alpha) - 1]$.

Equation (19) indicates that the collapse time is linked to the magnitude of the expected devaluation $(\bar{e}_H - \bar{e})$ and the length of the transitional float.[14] Crises occur earlier the greater the anticipated devaluation: Equation (19) shows that the higher the anticipated post-devaluation exchange rate, the sooner the speculative attack occurs $(\partial t_c/\partial \bar{e}_H < 0)$.[15] The relationship between the collapse time and the length of the floating-rate interval depends, in general, on the parameters of the model; it is negative for small T and positive for large T. If the transitional float is sufficiently brief, therefore, a speculative attack on the domestic currency will occur as soon as the private agents realize that the current exchange rate cannot be enforced indefinitely

1.2.3 | Real Effects of an Anticipated Collapse

Existing evidence suggests that balance-of-payments crises are often associated with large current-account movements during the periods preceding, as well as during the periods following, such crises. Typically, large external deficits tend to emerge as agents adjust their consumption pattern, in addition to adjusting the composition of their holdings of financial assets, in anticipation of a crisis. As suggested by the experience of Argentina, Chile, and Mexico reviewed below, for instance, movements in the real exchange rate and the current account can be quite dramatic. Such movements may provide an explanation of why speculative attacks are often preceded by a period during which official foreign reserves are lost at accelerating rates. Financial crises are also characterized by large output costs—typically an abrupt recession. Using panel data covering the period 1975–1997, Hutchison and Noy (2005), for instance, found that currency crises lead to reductions in output of about 5–8 percent over a two- to four-year period. Hong and Tornell (2005), using data for over 100 developing countries, found that following a currency crisis it takes less than three years for the *growth rate* of output to return fully to its pre-crisis average. The *level* of output, however, remains below its initial trend for a substantial period of time, suggesting that the effects of the shocks underlying a crisis are highly persistent.

A convenient framework for examining the real effects of exchange-rate crises was developed by Willman (1988), who assumes that domestic output is demand determined, positively related to the real exchange rate, and inversely related to the real interest rate.[16] The trade balance depends positively on the real exchange rate but is negatively related to aggregate demand. Prices are set as a markup over wages and imported input costs. In one variant of the model, nominal wages are determined through forward-looking contracts.[17] Under perfect foresight, an anticipated future collapse will affect wages immediately and, therefore, prices, the real exchange rate, output, and the trade balance. At the moment the collapse occurs, inflation jumps up, the rate of depreciation of the real exchange rate jumps down, and the real interest rate falls. As a result, output increases while the trade balance deteriorates. But because wage contracts are forward looking, anticipated future increases in prices are discounted back to the present and affect current wages. Consequently, prices start adjusting before the collapse occurs. The real interest rate falls gradually and experiences a downward jump at the moment the collapse takes place, as indicated above. The decline in the (ex post) real interest rate has an expansionary effect on domestic activity before the collapse occurs. However, output also depends on the real exchange rate. The steady rise in domestic prices results in an appreciation of the domestic currency, which has an adverse effect on economic activity and may outweigh the positive output effect resulting from a lower real interest rate. If relative price effects are strong, the net impact of an anticipated collapse on output may well be negative. The continuous loss of competitiveness, unless it is associated with a fall in aggregate demand (and thus downward pressure on the demand for imports), implies that the trade balance deteriorates in the periods preceding the collapse of the fixed exchange-rate regime. The trade deficit increases further at the moment the crisis occurs and, in association with a gradual depreciation of the real exchange rate, returns afterward to its steady-state level. The gradual appreciation of the real exchange rate until the time of collapse and the subsequent depreciation predicted by Willman's model account fairly well for the real exchange-rate movements observed during crisis episodes in countries such as Argentina in the early 1980s, as discussed below.

The role of intertemporal substitution effects in understanding the real effects of exchange-rate crises has recently been clarified by Kimbrough (1992),

[13] Formally, since $\kappa_0 = \alpha\gamma\mu$ and $\kappa_1 = 1$, these restrictions are given by

$$\bar{e} = \alpha\gamma\mu + \gamma(d_0 + \mu t_c) + C\exp(t_c/\alpha),$$

$$\bar{e}_H = \alpha\gamma\mu + \gamma[d_0 + \mu(t_c + T)] + C\exp[(t_c + T)/\alpha].$$

Direct manipulation of these equations yields the solutions for C and t_c given in Equations (19) and (20).

[14] Note that Equations (19) and (20) yield a solution for the collapse time that is equivalent to (17) with $R_l = 0$ and for $T \to \infty$, since in that case $\Omega \to 0$ and $(1-\gamma)R_0 = \bar{e} - \gamma d_0$.

[15] If $\bar{e}_H$ is high enough, it is possible that $t_c \leq 0$. In this case, the speculative attack occurs at the moment speculators learn that the fixed exchange rate cannot be defended indefinitely.

[16] Other models focusing on real exchange-rate effects of an anticipated collapse include those of Claessens (1991), Connolly and Taylor (1984), Connolly (1986), Calvo (1987*b*), and Veiga (1999).

[17] A formulation of wage contracts similar to the one proposed by Willman was used in Chapter 13.

who uses an optimizing framework in which money reduces transactions costs. Kimbrough shows that the effects of an anticipated speculative attack on the behavior of the current account depends crucially on the difference between the interest elasticity of the demand for money and the intertemporal elasticity of substitution in consumption. If the latter exceeds the former, an anticipated speculative attack raises consumption and real balances at the moment agents realize that the fixed exchange rate will eventually collapse, and leads to a continued deterioration of the current account until the attack actually takes place. By contrast, if the interest elasticity of the demand for money exceeds the intertemporal elasticity of substitution in consumption, the outcome is an initial reduction in consumption and real money balances, and an immediate and continued improvement in the current account until the time of the speculative attack and the collapse of the fixed exchange rate. An implication of Kimbrough's analysis is that anticipated speculative attacks may not be associated with similar real effects in all countries and at all times. Nevertheless, as discussed below for the case of several Latin American countries, speculative attacks and impending balance-of-payments crises have often been associated in practice with large current-account deficits.

1.2.4 | Borrowing, Capital Controls, and Crisis Postponement

Countries facing balance-of-payments difficulties often have recourse to external borrowing to supplement the amount of reserves available to defend the official parity, or impose restrictions on capital outflows in an attempt to limit losses of foreign exchange reserves. In the basic model developed above, it is assumed that there is a critical level, known by everyone, below which foreign reserves are not allowed to be depleted. However, such a binding threshold may not exist. A central bank facing a perfect capital market can, at least in principle, increase foreign reserves at its disposal by short-term borrowing. Negative (net) reserves are therefore also feasible.

In fact, perfect access to international capital markets implies that, at any given point in time, central bank reserves can become negative without violating the government's intertemporal solvency constraint. Unlimited access to borrowing could therefore postpone or avoid a regime collapse. The rate of growth of domestic credit cannot, however, be permanently maintained above the world interest rate, because it would lead to a violation of the government budget constraint (Obstfeld, 1986*c*). In this sense, an over-expansionary credit policy would still ultimately lead to the collapse of a fixed exchange-rate regime.[18] Moreover, even with perfect capital markets, the timing of borrowing matters considerably for the nature of speculative attacks. Suppose that the interest cost of servicing foreign debt exceeds the interest rate paid on reserves.

[18] The relation between speculative attacks and the solvency of the public sector in an economy with interest-bearing debt has also been examined by Ize and Ortíz (1987).

If borrowing occurs just before the fixed exchange rate would have collapsed without borrowing, the crisis is likely to be postponed. If borrowing occurs long enough before the exchange-rate regime would have collapsed in the absence of borrowing, the crisis would occur earlier. The reason the collapse is brought forward is, of course, related to the servicing cost of foreign indebtedness on the public sector deficit, which raises the rate of growth of domestic credit (Buiter, 1987).

In practice, most developing countries face borrowing constraints on international capital markets. The existence of limited access to external financing has important implications for the behavior of inflation in an economy where agents are subject to an intertemporal budget constraint. Consider, for instance, a country that has no opportunity to borrow externally and in which the central bank transfers its net profits to the government. If a speculative attack occurs, the central bank will lose its stock of reserves, and its post-collapse profits from interest earnings on those reserves will drop to zero. As a consequence, net income of the government will fall and the budget deficit will deteriorate. If the deficit is financed by increased domestic credit—a typical situation for a developing country with limited access to domestic and external borrowing—the post-collapse inflation rate will exceed the rate that prevailed in the pre-collapse fixed exchange-rate regime, raising inflation tax revenue to compensate for the fall in interest income (van Wijnbergen, 1991).

As indicated earlier, capital controls have often been used to limit losses of foreign exchange reserves and postpone a regime collapse. Such controls have been imposed either permanently or temporarily after the central bank had experienced significant losses, or at times when the domestic currency came under heavy pressure on foreign exchange markets.[19] With permanent controls, as shown by Agénor and Flood (1994), the higher the degree of capital controls, the longer it will take for the fixed exchange rate to collapse. This is because controls dampen the size of the expected future jump in the domestic nominal interest rate and the associated shift in the demand for money.

The effect of temporary capital controls on the timing of a balance-of-payments crisis was studied by Bacchetta (1990), who showed that temporary restrictions on capital movements may have pronounced real effects. In a perfect-foresight world, agents will anticipate the introduction of controls as soon as they realize the fundamental inconsistency between the fiscal policy and the fixed exchange rate. However, it is now critical to distinguish the case in which the timing of the policy change is perfectly anticipated and the case in which it is not. If controls take agents by surprise, capital outflows will increasingly be replaced by higher imports once such controls are put in place,

[19] In developing countries, capital controls have often been of a permanent nature; see, for instance, Edwards (1989*a*) for Latin American countries. Temporary controls have typically been used in industrial countries, notably in Europe.

leading eventually to a deterioration in the current account until a "natural" collapse occurs. The accelerated rate of depletion of foreign reserves through the current account will therefore precipitate the crisis, defeating the initial objective of controls. If capital controls are preannounced, or if agents are able to "guess" correctly the exact time at which controls will be introduced, a speculative attack may occur just before the controls are imposed, as agents attempt to readjust their portfolios and evade restrictions. Such an attack will, again, defeat the very purpose of capital controls and may in fact precipitate the regime collapse (Dellas and Stockman, 1993). These results are consistent with the empirical estimates of Glick and Hutchison (2005), based on panel data regressions for sixty developing countries for the period 1975–97, which suggest that restrictions on capital flows typically do not appear to effectively insulate countries from speculative attacks and currency crises.

1.2.5 | Interest Rate Defense

The standard model of currency crises described earlier implicitly assumes that the central bank remains passive while official foreign reserves dwindle. In practice, central banks typically defend pegs aggressively by raising short-term interest rates (see Montiel, 2003). Contributions by Lahiri and Végh (2003) and Flood and Jeanne (2005) have amended the conventional model of speculative attacks, which is based on perfect capital mobility (and thus "ties" the domestic interest to the foreign rate under the fixed exchange-rate regime) to feasibility and optimality of interest rate hikes in delaying currency crises. To do so, both studies introduce frictions in the degree of substitution between assets.

In the model of Lahiri and Végh (2003), interest rate policy operates in conflictive ways. By raising demand for domestic, interest-bearing liquid assets, higher interest rates tend to delay the crisis. At the same time, however, higher interest rates increase public debt service and may signal higher future inflation (if the ensuing deficit cannot be closed by higher taxes), which tends to bring forward the crisis. Depending on the conditions, it is feasible to delay the crisis, but raising interest rates beyond a certain point may actually hasten it. It is thus optimal to engage in some active interest rate defense, but only up to a certain point. In Flood and Jeanne (2005), increasing the domestic currency interest rate before a speculative attack makes domestic assets more attractive as a result of an asset substitution effect, but weakens the domestic currency by increasing the government's fiscal liabilities.[20] Thus, an interest rate defense can be successful only if the initial level of public debt is not too large.

[20] To generate imperfect substitutability between domestic and foreign assets, Flood and Jeanne assume that holding foreign bonds generates disutility. This assumption is rather arbitrary and far from intuitive. A more attractive approach would be to introduce individual risk, along the lines of the model discussed in Chapters 12 and 14. This would yield a formulation similar to (5) in their paper.

In contrast to the above contributions, Drazen and Hubrich (2006) suggest that the benefit of high interest rates to fend off speculative attacks stems mainly from the signal that they provide—rather than from their direct impact on the profitability of speculation. As discussed in more detail later, by raising interest rates, policymakers may signal their commitmnt to fixed exchange rates, but it may also signal weak fundamentals. Hence, while raising interest rates may lead to the expectation that future rates will be high, it may also increase the probability speculators assign to a collapse of the pegged exchange rate. The net effect may therefore be ambiguous—as found in many empirical studies focusing on summary measures of the outcome of speculative attacks (see Montiel, 2003).

1.2.6 | Other Directions

There are many other directions in which the theory of balance-of-payments crises has been extended, particularly in the areas of uncertainty (over the critical threshold of reserves, for instance, or the credit policy rule) and regime switches (see Agénor and Flood, 1994). The introduction of uncertainty on domestic credit growth provides a channel through which the sharp increases in domestic nominal interest rates that typically precede an exchange-rate crisis can be explained.[21] But beyond being consistent with rising interest rates prior to the crisis, the introduction of uncertainty in collapse models has several additional implications. First, the transition to a floating-rate regime becomes stochastic, implying that the collapse time is a random variable that cannot be determined explicitly, as before. Second, there will, in general, always be a nonzero probability of a speculative attack in the next period, a possibility that in turn produces a forward discount on the domestic currency—the so-called "peso problem" (Krasker, 1980). Available evidence indeed suggests that the forward premium—or, as an alternative indicator of exchange-rate expectations in developing countries, the parallel market premium—in foreign exchange markets tends to increase well before the regime shift. Third, the degree of uncertainty about the central bank's credit policy plays an important role in the speed at which reserves of the central bank are depleted (Claessens, 1991). In a stochastic setting, reserve losses exceed increases in domestic credit because of a rising probability of regime collapse, so that reserve depletion accelerates on the way to the regime change. As indicated above, such a pattern has often been observed in actual crises.

Early models of balance-of-payments crises have been generally limited to the consideration of an exogenous rate of credit growth that has been, often implicitly, taken to reflect "fiscal constraints." The apparently ineluctable nature of a regime collapse that such an assumption entails runs into a

[21] There have been many applications of the stochastic model of exchange-rate crises. See, in particular, Cumby and van Wijnbergen (1989) for Argentina, and Blanco and Garber (1986), Connolly and Fernández (1987), and Goldberg (1994) for Mexico.

conceptual difficulty—namely, why is it that policymakers do not attempt to prevent the crisis by adjusting their fiscal and credit policies? For instance, there is nothing in the basic model developed above that requires the central bank to float the currency and abandon the prevailing fixed exchange rate at the moment reserves hit their critical lower bound. Instead, the central bank could choose to change its credit policy rule (before reserves are exhausted) to make it consistent with a fixed exchange-rate target. Some recent models of balance-of-payments crises have indeed considered endogenous changes of this type in monetary policy. Drazen and Helpman (1988) and Edwards and Montiel (1989), in particular, have emphasized that the assumption that the authorities choose to adjust the exchange rate instead of altering the underlying macroeconomic policy mix can provide only a temporary solution. Ultimately, if the new exchange-rate regime is inconsistent with the underlying fiscal policy process, there will be a need for a new policy regime.

Finally, an area that has received much attention in the recent literature is the possibility of multiple equilibria. Instead of assuming, as in the basic Krugman–Flood–Garber model, that credit policy is exogenous, several authors have explored the implication of an endogenous credit policy rule. Specifically, Obstfeld (1986*c*) has examined the case where domestic credit growth is consistent with the indefinite viability of the fixed exchange rate as long as the regime is maintained ($\mu = 0$), but contingent on the collapse of the fixed exchange rate, the loss of discipline causes the domestic credit growth rate to increase ($\mu \geq 0$). In such a setting, multiple equilibria may emerge. The fixed exchange rate can survive indefinitely if asset holders believe that it will not collapse. By contrast, if private agents believe that a collapse will occur, the run on official reserves will bring the regime down, triggering the contingent shift in domestic credit growth, and validating the attack. Formally, consider the case where $\mu = 0$ in the basic framework developed previously. From (14), $t_c = \infty$, and the regime survives indefinitely. Suppose that, contingent on a collapse of the fixed exchange rate, agents expect credit growth to be $\mu_c > 0$ and that $\Theta(R_0 - R_l)/\mu_c < \alpha$, so that $t_c < 0$. Then an immediate attack will take place; the post-attack solution for the floating rate will jump upward, or at least start depreciating sufficiently rapidly to ratify the sudden reduction in the domestic money stock. Thus, private agents' beliefs about the viability of the fixed exchange rate become a key element in determining the timing of the crisis. Shifts across alternative equilibria may be self-fulfilling: the economy may switch from an equilibrium in which devaluation expectations are low and the peg is sustainable, to an equilibrium in which devaluation expectations are high and the peg becomes impossible to defend.

Models of currency crises with multiple equilibria have been extended in various directions in recent years. The next section discusses the main features of these models.

2 | Policy Trade-Offs and Self-Fulfilling Crises

A key feature of the recent literature on currency crises has been, in addition to a focus on multiple equilibria, an explicit modeling of policymakers' preferences and policy rules. In this setting, policymakers are viewed as deriving benefits from pegging the currency—by, say, "importing" the anti-inflation bias of the foreign central bank—but as also facing other policy objectives—such as the level of unemployment and domestic interest rates. Thus, depending on the circumstances that they face, policymakers may find it optimal to abandon the official parity.

According to this approach, the occurrence of an exchange-rate "crisis" is not related to the existence of a sufficient level of reserves. Rather, the abandonment of the peg is the result of the implementation of a *contingent rule* for setting the exchange rate. Each period, the policymaker considers the costs and benefits associated with maintaining the peg for another period, and must decide, given the relative weights attached to each policy objective, whether or not to abandon it. This decision typically is viewed as depending on the realization of a particular set of domestic or external shock(s). For a given cost associated with abandoning the currency peg, there exists a range of values for the shock(s) that makes maintaining the peg optimal. However, for sufficiently large realizations of the shock(s), the loss in flexibility associated with the discretionary use of the exchange rate may exceed the loss incurred by abandoning the peg; in such circumstances, it is optimal for the policymaker to operate a regime switch.

2.1 | Example Based on Output–Inflation Trade-Offs

A tractable framework that allows understanding the main features of models with "rational" or optimizing policymakers and the role of self-fulfilling factors is the model developed by Obstfeld (1996), which emphasizes trade-offs between output (or unemployment) and inflation.[22]

Suppose that the government's loss function is given by

$$L = (y - \tilde{y})^2 + \theta \Delta e^2 + c, \quad \theta > 0 \tag{21}$$

where y is (the log of) output, $\tilde{y}$ the policymaker's output target, e (the log of) the exchange rate, and c a fixed cost associated with changes in the official parity. Output is determined by an expectations-augmented Phillips curve

$$y = \bar{y} + \alpha(\varepsilon - \varepsilon^a) - u, \tag{22}$$

where $\bar{y}$ is the "natural" (or long-run) level of output, $\varepsilon \equiv \Delta e$, ε^a domestic price-setters' expectation of ε, and u is a zero-mean shock. As in Barro–Gordon type models, we assume that $\tilde{y} > \bar{y}$.

[22] The Appendix to this chapter introduces an alternative loss function, in the context of a model of credibility and reputational factors developed by Agénor and Masson (1999).

Price setters form their expectations prior to observing the shock u. By contrast, the policymaker chooses e after observing the shock. A devaluation bears a cost of c^d, and a revaluation cost of c^r.

Begin by ignoring the term c in (21). With ε^a predetermined, the policymaker chooses

$$\varepsilon = \frac{\alpha(\tilde{y} - \bar{y} + u) + \alpha^2 \varepsilon^a}{\alpha^2 + \theta}, \tag{23}$$

which implies a level of output equal to

$$y = \bar{y} + \frac{\alpha^2(\tilde{y} - \bar{y}) - \theta u - \alpha\theta\varepsilon^a}{\alpha^2 + \theta},$$

and a policy loss of (with the superscript D for discretionary):

$$L^D = \frac{\theta}{\alpha^2 + \theta}(\tilde{y} - \bar{y} + u + \alpha\varepsilon^a)^2.$$

If the government foregoes the use of the exchange rate (so that $\Delta e = 0$), the policy loss is instead, substituting (22) in (21),

$$L^F = (\tilde{y} - \alpha\varepsilon^a - u - \bar{y})^2.$$

Consider now the fixed cost c. When fixed costs exist, Equation (23) holds only when u is so large that $L^D + c^d < L^F$, or so low that $L^D + c^r < L^F$. A devaluation (revaluation) thus takes place for $u > u^d$ $(< u^r)$, where

$$u^d = \frac{1}{\alpha}\sqrt{c^d(\alpha^2 + \theta)} - (\tilde{y} - \bar{y}) - \alpha\varepsilon^a,$$

$$u^r = -\frac{1}{\alpha}\sqrt{c^r(\alpha^2 + \theta)} - (\tilde{y} - \bar{y}) - \alpha\varepsilon^a.$$

Suppose that u is uniformly distributed in the interval $(-\nu, \nu)$. The rational expectation of next period's ε, given price-setters' expectation ε^a, is given by

$$E\varepsilon = E(\varepsilon \mid u < u^r)\Pr(u < u^r) + E(\varepsilon \mid u > u^d)\Pr(u > u^d),$$

or, using Equation (23):

$$E\varepsilon = \frac{\alpha}{\alpha^2 + \theta}\left[\left(1 - \frac{u^d - u^r}{2\nu}\right)(\tilde{y} - \bar{y} + \alpha\varepsilon^a) - \frac{u^{d2} - u^{r2}}{4\nu}\right]. \tag{24}$$

In full equilibrium, $E\varepsilon = \varepsilon^a$. Equation (24) is shown in Figure 15.2. As shown by Obstfeld (1996), the slope of the curve describing the relationship between $E\varepsilon$ and ε^a is given by, setting $\Delta = \alpha^2 + \theta$:

$$\frac{dE\varepsilon}{d\varepsilon^a} = \begin{cases} \alpha^2\Delta^{-1} & \text{for } u^r > -\nu \\ \alpha^2\Delta^{-1}\left[\frac{\alpha}{2} + \frac{\alpha}{2\nu}(\tilde{y} - \bar{y} + \alpha\varepsilon^a)\right] & \text{for } u^r = -\nu. \\ \alpha^2\Delta^{-1} & \text{for } u^d = -\nu \end{cases}$$

There are, therefore, three possible equilibria (or, more precisely, three equilibrium expected depreciation rates) in this model, corresponding to

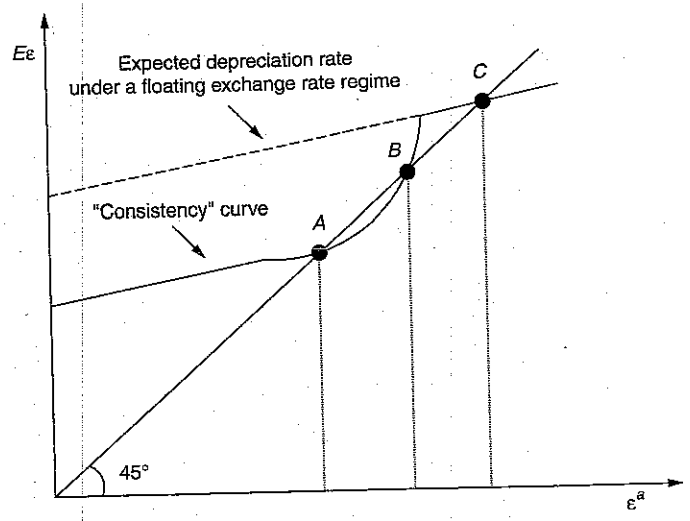

Figure 15.2
Multiple Equilibria in a Model of Self-Fulfilling Exchange-Rate Crisis.
Source: Adapted from Obstfeld (1996, p. 1043).

three different probabilities of devaluation and realignment magnitudes—conditional on a devaluation taking place. These equilibria are denoted by points A, B, and C in the figure. Once ε^a is sufficiently high for u^d to remain at $-\nu$, the government's reaction function is given by (23) and the expected depreciation rate is the same as under a flexible exchange-rate regime—obtained by setting $\varepsilon = \varepsilon^a$ in (23):

$$\varepsilon = \varepsilon^a = \frac{\alpha(\tilde{y} - \bar{y} + u)}{\theta}.$$

To ensure that equilibrium C in Figure 15.2 exists, a necessary condition for multiplicities to exist, requires the restriction

$$\theta^{-1}\Delta(\tilde{y} - \bar{y}) - \nu \geq \alpha^{-1}\sqrt{c^d\Delta},$$

a condition that can be interpreted as indicating that if private agents form an expectation of the average depreciation rate of the floating exchange rate, then it will materialize—as long as the fixed devaluation cost is not too high. Thus, as long as market expectations gravitate around a nonzero depreciation rate, the policymaker will be unable to enforce its preferred equilibrium (which involves zero depreciation). Furthermore, a small random event could shift the exchange rate from a position where it is vulnerable to only very "bad" realizations of the shock, to one where output is so low (in the absence of a devaluation) that even small shocks will induce the policymaker to devalue the currency.

2.2 | Public Debt and Self-Fulfilling Crises

The role of public debt in generating self-fulfilling currency crises is highlighted in several contributions, most notably by Cole and Kehoe (1996) and Velasco (1996, 1997).[23] The Cole–Kehoe model, in particular, emphasizes the role of a short average term of a country's public external debt in allowing a potentially temporary loss of investor confidence to produce a severe and persistent economic crisis. The implication of their analysis is that financial crises (of the type that occurred in Mexico in December 1994, as discussed later) can be avoided if governments diversify the term structure of their debt sufficiently to ensure that only a small portion of it matures during any particular interval of time.

In the Cole–Kehoe model, the government inherits a certain amount of foreign debt that it must either retire, refinance, or repudiate.[24] They focus on the case in which the initial stock of public debt is so large that it is either not feasible to repay it in one period or can be immediately retired only at the cost of a very significant loss in welfare. However, repudiating the debt, although costly (it may permanently reduce the productivity of the economy), may be preferable to retiring or refinancing the debt under some circumstances. The government, moreover, cannot credibly commit itself to refusing to repudiate the debt at a future date if repudiation turns out to be the "best" strategy at that date.

Cole and Kehoe show that if the initial debt is large enough it is possible for the model to admit multiple equilibrium outcomes, depending on the nature of foreign lenders' expectations. If foreign lenders expect the government to be able to service its debts, then government bonds will sell at a moderate price and it will be optimal for the government to refinance them rather than repudiate them. If, on the other hand, lenders believe, for whatever reason(s), that the government will not be able to service its debts, then they will be unwilling to lend to the government. Under such conditions the government cannot possibly refinance its debt and it may be optimal to repudiate it rather than accept the large (and possibly infeasible) loss in consumption that would be necessary to extinguish foreign liabilities out of the country's current income. Thus, foreign lenders' expectations that the government will not be able to service its debt are self-fulfilling; when lenders hold this expectation, the government becomes unwilling or unable to service its debt. This situation

[23] See also Corsetti and Mačkowiak (2006) for a discussion of how external nominal shocks can cause fiscal imbalances and undermine currency stability, and how fiscal and interest rate policies interact to determine the magnitude and timing of speculative attacks.

[24] For the purpose of this discussion, it is important to distinguish between repudiating a debt, which is a decision not to repay any portion of it at any future date, and defaulting on a debt, a broader term that could include not only repudiation but also such actions as repaying only part of the principal or interest on the debt or unilaterally extending the term of the debt. When Cole and Kehoe use the term *default*, they are actually talking about repudiation.

can arise *stochastically*; that is, there can be equilibria in which lenders expect the government to be able to repay its debts, in which case the government refinances them and no crisis occurs, but occasionally lenders may expect the government to be unable to repay, in which case the government cannot refinance the debt and chooses to repudiate it, producing a crisis. Formally, these "bad" states of nature are tied to adverse realization of a spurious indicator variable—a sunspot, that is, a seemingly minor random event, such as the resignation of some key economic minister. There can be only one crisis, however, because after the government has repudiated its debt (thereby losing its reputation) it no longer has the option to borrow.

In the Cole–Kehoe model, a financial crisis can occur at a particular date only if the amount of debt that needs to be rolled over at that particular date is fairly large. As a result, changing the maturity structure of the debt can prevent crises from occurring. If the government refinances its initial debt by issuing bonds with varying maturities, then only a fraction of it would need to be refinanced at any particular future date. Under such conditions, even if lenders are led to believe (whatever the reason may be) that the government is going to be unable to refinance its debt, the government can retire maturing debt out of its current income without incurring welfare costs large enough to give it the incentive to repudiate its debt. Under these conditions an equilibrium in which self-fulfilling beliefs by lenders that the government will fail to repay does not exist and a crisis cannot occur.

2.3 | Role of Credibility and Reputation

The role of credibility and reputational factors in models of currency crises with optimizing policymakers (through their effect on exchange-rate expectations) has been emphasized by Drazen and Masson (1994). The notion of credibility on which these models dwell consists of two elements: an assessment of the policymaker's "type" (which would be termed reputation), and (given the type of policymaker) an assessment of the probability that a policymaker will actually decide to stick to announced policies in the presence of adverse shocks. In the context considered here, the policy commitment is to maintain an exchange-rate peg in the face of shocks to reserves.

As argued by Drazen and Masson (1994), resisting a currency crisis can actually undermine, rather than enhance, the credibility of a pegged exchange rate. High interest rates, for instance, may signal the government's commitment to the peg and thus enhance credibility, but at the same time it may also worsen fundamentals, making the economy more vulnerable to adverse shocks. Thus, the most rigid policy is not necessarily optimal; in an uncertain economic environment, and if shocks are persistent, there may be a trade-off between credibility and flexibility.[25]

[25] Neut and Velasco (2004) propose a related argument, albeit in a different framework.

A straightforward application of these ideas is a study by Irwin (2004), on whether a currency board necessarily provides a durable basis for a fully binding and credible commitment to fix the exchange rate. Irwin develops a model in which a currency board is abandoned when the (political) cost of maintaining the peg is sufficiently high. A credibility problem exists because agents have incomplete information about the magnitude of this cost. If policymakers face a high cost of devaluation, they will maintain the currency board, but at the expense of higher unemployment. This tends to reduce the credibility of the exchange-rate peg. At the same time, because the public learns about the true devaluation cost by observing actual exchange-rate behavior, maintaining the currency board will help to improve its credibility. If the first effect dominates, fundamentals will tend to deteriorate over time. Specifically, if unemployment is persistent, the credibility problem will be compounded, and the pressure to devalue and abandon the currency board will increase over time. Ultimately, even a policymaker who faces a very high cost of devaluation can be forced to devalue. In a sense, this conclusion is similar to Drazen and Masson (1994) regarding the sustainability of conventional pegs.

A more substantial extension of the Drazen–Masson framework is given by Benigno and Missale (2004), who account explicitly for public debt, using a three-period stochastic setting that emphasizes output–inflation trade-offs. In their model, the decision to devalue or maintain the peg depends on the realization of an output shock. Because of uncertainty, a devaluation leads to unexpected inflation, which increases output, both through a standard price-output effect and through the reduction of the distortionary taxes associated with nominal debt service. Whether the exchange-rate regime gains or loses credibility after a successful defense cannot be determined a priori. On the one hand, resisting a crisis enhances the credibility of the government and thus the expectation that the peg will be maintained. This "signaling" effect is important when there is substantial uncertainty about the government's cost of devaluation and when the level of public debt is low. On the other, defending the parity and refraining from inflationary financing increases the debt burden, hence the likelihood of a forced future devaluation. This "debt-burden" effect is important when the debt is large and there is little uncertainty about the government's cost of devaluation. Which effect prevails depends on the relative importance of the government's reputation and the fundamentals.

When the government's preferences are publicly known, only the fundamentals matter; a devaluation always increases the probability that a future defense of the new parity will succeed. In this case the probability of a first-period devaluation increases with the size of the public debt and with the share of it that is short-term—as in models of self-fulfilling crises. By contrast, when the government's preferences are not publicly known, the decision to devalue may reveal a weak government heading to further devaluation, which generates inflationary expectations and higher interest rates. This creates an incentive to defend the fixed parity both for a tough government, to signal its type, and for a weak one, in order to appear tough. Thus, reputation motives increase the probability that the parity will be maintained.

2.4 | Other Sources of Policy Trade-Offs

Various other sources of policy tradeoffs have been discussed in the recent literature on self-fulfilling crises. Some, in particular, rely either directly or indirectly on the (adverse) effects of higher interest rates. For instance, banks may come under pressure if market interest rates rise unexpectedly. To avoid a costly bailout, the policymaker may want to implement a quick devaluation. Or, with sticky domestic prices, a hike in nominal interest rates may imply hikes in short-term real rates, and these may generate self-fulfilling devaluation pressures (see Ozkan and Sutherland, 1998).

The very existence of (implicit) government guarantees may also lead to a self-fulfilling financial crisis. As argued by Burnside (2004), by taking on a contingent liability, the government can actually increase the probability with which the underlying event takes place. For instance, in the face of (credible) government guarantees, banks' behavior may change in such a way that the banking system becomes more fragile—perhaps by inducing banks to take on more exchange-rate risk. Thus, the government becomes more likely to incur the fiscal cost associated with bank failures. And incurring this fiscal cost, in turn, makes the probability of bank failures higher. Further, as shown in Burnside (2004) and Burnside et al. (2004), this raises the likelihood of self-fulfilling speculative attacks. If agents come to believe that the exchange-rate regime will collapse, they will speculate against local currency, ultimately causing the central bank to float the exchange rate. The central bank's decision to float, in turn, will lead to depreciation of the currency—in anticipation of the government choosing to print money—which will ultimately lead to the failure of unhedged banks. These bank failures will, in turn, require the government to honor its bailout guarantee. When it does so by printing money, it validates the speculative attack.

In all of these models, "fundamentals," viewed as reflecting the policymaker's preferences and the economy's structure, affect the multiplicity of equilibria. But the policymaker is incapable of enforcing its preferred equilibrium, should market expectations focus on an inferior one. Further, "sunspots" could shift the exchange rate from a position where it is vulnerable to only very bad realizations of a shock—a phenomenon with very low ex ante probability—to one where output is so low absent devaluation that even "small" shocks will induce the authorities to devalue or to adopt a floating-rate regime.

Finally, it is worth noting that the role of (incomplete) information in self-fulfilling models of currency crises has been a matter of much debate. In an important contribution, Morris and Shin (1998) considered the case where

speculators, having a uniform prior probability distribution over the state of fundamentals, update it according to the observation of a private signal. Lack of common knowledge is thus the driving force of their model. They show that the indeterminacy of equilibria that characterizes models of self-fulfilling currency crises can be completely removed, once a small degree of uncertainty about the true fundamentals is introduced. Put differently, multiplicity in their analysis is the consequence of assuming that fundamentals are common knowledge among market participants; if, instead, traders observe the relevant fundamentals with a small amount of idiosyncratic noise, a unique equilibrium can be selected.

Heineman and Illing (2002) extended the analysis of Morris and Shin to consider a broader class of probability distributions. They also show that increased transparency (in the sense of providing more precise information about fundamentals, namely, government policy) may reduce the likelihood of speculative attacks. Sbracia and Zaghini (2001) extend their analysis to examine the role of the distribution of agents' beliefs about fundamentals. They show that currency crises can be triggered by "small" changes in the distribution of agents' beliefs, even without any underlying deterioration of the fundamentals. Hellwig et al. (2006) extend their analysis to consider explicitly domestic asset markets and interest rates. By comparing the solution when fundamentals are common knowledge with the solution when traders have idiosyncratic, noisy signals, they find that (in contrast to Morris and Shin), arguments for multiplicity remain valid even in the presence of incomplete, heterogeneous information. The source of multiplicity, however, is not a coordination problem (as postulated in Morris and Shin) but rather the nonmonotonicity of trading strategies (which does not depend on the fact that private signals are noisy).

3 | A "Cross-Generation" Framework

Flood and Marion (1999) have recently proposed a "cross-generation" framework for the analysis of currency crises. They argue that the key difference between the "old" and the "new" approaches is that the former assumes that the commitment to a fixed exchange is *state invariant*, whereas in the latter it is *state dependent*—a feature that captures well the evidence suggesting that policymakers respond to various objectives.

One way of linking the two generations of models, as suggested by Flood and Marion (1999), is to make the threshold level of reserves in the conventional approach a function of a variable that captures the state of the business cycle (such as the level of unemployment and the rate of inflation). Endogenizing R_t (rather than assuming it is fixed as in the standard model) has the implication that the policymaker may affect the behavior of the shadow exchange rate over time (and thus the size of the exchange-rate jump upon which a speculative attack depends) through its choice of the level of reserves

that it wants to commit to defend the parity—or equivalently, the level at which it chooses to abandon it.[26] Although the potential profits to be realized by speculators remain the driving force behind speculative attacks in this framework, the state of the economy also influences the timing of currency crises—as in the new generation models.

Another attractive property of the cross-generation framework proposed by Flood and Marion is that it restricts the apparently large degree of arbitrariness (associated with self-fulfilling factors) that characterizes the timing of speculative attacks in second-generation models. There are ranges in which multiple equilibria do occur, but this happens only if (some of) the fundamentals are sufficiently out of line. From the point of view of policymakers, this appears to be a more sensible prediction than simply emphasizing the role of "sunspots." Nevertheless, more research remains necessary to fully reconcile the two generations of models.

4 | Third-Generation Models

Third-generation models of currency crises give a key role to financial structure fragility and financial institutions. From a modeling perspective, there are three main approaches. A first approach, sketched by Krugman (1998), involves moral-hazard-driven investment, which leads to overinvestment, overborrowing, and eventually to the collapse of the banking system. A second approach, promoted by Chang and Velasco (2000*a*, 2000*b*, 2001), explains abrupt reversals in inflows as a byproduct of bank runs due to an internationally illiquid banking sector (see Chapter 16). A self-fulfilling loss of confidence of depositors and foreign investors forces financial intermediaries to liquidate their investments prematurely.

A third approach stresses the balance sheet implications of currency depreciation. Third-generation models of currency crises have in common the idea that the crisis can be seen as a result of an adverse shock (real or financial) that was amplified by credit market imperfections, and more specifically a financial accelerator mechanism. Specifically, credit-constrained firms with a high proportion of debt denominated in foreign currency are vulnerable to a self-fulfilling fear of insufficient collateral, as this expectational shift triggers a capital outflow that causes a real devaluation. Krugman (1999), Caballero and Krishnamurthy (2001), and Aghion et al., (2001, 2004*a*) have spearheaded this approach.

In the models developed by Aghion et al., for instance, the key source of (self-fulfilling) currency crises is the interplay between credit or balance sheet constraints faced by private domestic firms—of the type discussed in Chapter 6, in reference to the Kiyotaki–Moore model—and the existence

[26] Strictly speaking, the choice of the threshold level of reserves is the choice of the parameters linking R_t to the variable capturing the state of the economy.

of nominal price rigidities. The possibility of multiple equilibria, including a currency crisis equilibrium with low output and a depreciated domestic currency, results from the following mechanism: if nominal prices are sticky in the short run, a currency depreciation leads to an increase in the foreign-currency debt repayment obligations of firms, and thus to a fall in profits in the current period—which lowers firms' net worth and their borrowing capacity. Tighter credit constraints tend to reduce investment and output in the next period, which in turn lowers the demand for the domestic currency and leads to a depreciation. Arbitrage in the foreign exchange market then implies that the currency must depreciate in the current period as well. Thus, the currency depreciation becomes self-fulfilling. In general, multiple short-run equilibria are possible; a currency crisis occurs either when expectations change or when a real shock shifts the economy to the "bad" equilibrium with low output. Nevertheless, the primary source of crises is the deteriorating balance sheets of private firms. Gertler et al. (2007) found that balance sheet effects help to explain the output contraction that occurred following the East Asian currency crisis. Similarly, using data on Mexican firms in the aftermath of the December 1994 peso crisis, Aguiar (2005) found that firms with heavy exposure to short-term foreign currency debt before the devaluation experienced a marked drop in investment after the currency was floated. This effect is particularly significant for exporters, which borrowed disproportionately in foreign currency. Weak balance sheets therefore explain much of the recessionary impact of the currency depreciation.

Another contribution along these lines is by Paasche (2001), who extended the Kiyotaki–Moore model of credit cycles to a three-country setting and studied how crises are transmitted internationally. Two of the countries are small and their domestic firms, which produce a differentiated commodity that they export to a large country, face credit constraints. Moreover, the small countries have no direct economic linkages; the only link between them is the elasticity of substitution in the consumption of their exports by the large country. A productivity shock to one of the small countries triggers an adverse term-of-trade shock to the other which is then amplified by credit constraints—possibly triggering large capital outflows and a sharp deterioration in the current account. Domestic financial frictions may therefore explain the transmission of contagious shocks between small open economies, even in the absence of direct trade or financial linkages.

This class of models is also useful to understand the impact of monetary policy on output in the presence of credit constraints. In Christiano et al. (2004) and Devereux and Poon (2004), for instance, the firms' borrowing constraint is not binding in "normal" times; it becomes binding only in "crisis" times. In both cases, the optimal response of monetary policy in response to shocks varies across states of nature. In particular, as shown in the first paper, following an unexpected tightening of external collateral constraints, a cut in official interest rates can either lead to an expansion (because higher asset prices induced by the interest rate cut leads to an improvement in firms' balance sheets, and thus a weaker constraint on borrowing) or a contraction (because a depreciation lowers the demand for imported intermediate goods, and thus employment and output). In a related paper, Aghion et al. (2000) also find that the impact of an interest rate cut on economic activity in an open-economy model is ambiguous.

5 | Evidence on Exchange-Rate Crises

We now briefly review recent experiences with exchange-rate and balance-of-payments crises in four developing countries in the 1980s (Argentina, Brazil, Chile, and Mexico), as well as the Mexican peso crisis of December 1994 and the Thai baht crisis of 1996. In many regards, the early experiences are fairly representative of the "conventional" characteristics of these phenomena. The more recent crises, by contrast, help illustrate the importance of self-fulfilling factors, as emphasized in the recent literature.[27]

5.1 | The Mexican Peso Crisis (December 1994)

Over the past two decades, Mexico has served as a bellwether for changes in the international financial environment facing developing countries. In the 1974–1981 prelude to the international debt crisis, Mexico led the way in the accumulation of external bank debt, and was the largest developing-country debtor when the crisis struck. The crisis itself was bracketed by events in Mexico; it was triggered by Mexico's announcement of its inability to service external debt in August 1982, and the beginning of its end, at least for the major debtors, was marked by the agreement of a Brady deal between Mexico and its external bank creditors in 1989. This date also marked the beginning of a new international financial regime for developing countries, one in which portfolio capital and foreign direct investment flowed abundantly to the private sector in several countries that had previously undertaken serious programs of stabilization and market-oriented structural reforms. Once again, Mexico was in the vanguard, accounting by itself for 30 percent of total portfolio flows to developing countries over the period from 1989 to mid-1993.

These flows came to an abrupt end in December 1994, when Mexico experienced a severe crisis, which had repercussions throughout international financial markets. This crisis, as well as the Thai baht crisis described

[27] There is limited empirical evidence on whether these crises can be characterized as "self-fulfilling" or not. Bratsiosis and Robinson (2004) found some evidence of self-fulfilling expectations in the 1994 Mexican peso crisis. The key variables that appear to have generated multiple equilibria and affected the devaluation probability were the large switch from peso- to U.S. dollar-denominated debt, the real exchange-rate appreciation, and the increases in unemployment and the primary deficit. See also Ratti and Seo (2003).

next, provide useful illustrations of the types of phenomena captured in the new generation of crisis models, in which policymakers' preferences among competing macroeconomic objectives are part of the "fundamentals" determining the timing of speculative attacks and regime switches.

5.1.1 | Background: Structural Reforms and the Solidarity Pact

Although Mexico had traditionally been a low-inflation country, expansionary fiscal policies associated with the oil bonanza after 1976 resulted in a combination of high inflation, capital flight, and rapid accumulation of external debt. The onset of the international debt crisis, triggered by the country's inability to service its debt, ushered in three years of very poor macroeconomic performance, featuring triple-digit inflation and negative growth. A thoroughgoing program of reform and orthodox stabilization was finally undertaken in 1985. Structural reform was both broad and deep, including fiscal adjustment, privatization, trade and financial liberalization, as well as reform of the foreign investment regime. The key macroeconomic policy objectives were inflation stabilization and a reactivation of growth based on improvements in economic efficiency.

As described in Chapter 9, after an initial orthodox program of inflation stabilization yielded disappointing results, Mexico switched to a heterodox approach in 1987. The key heterodox component of this plan was an agreement (Pacto) among the government, business, and labor that sought to break inflation inertia by setting three nominal anchors for the economy, based on the nominal variables influenced by each set of agents. The government undertook to restrict increases in public sector prices and the exchange rate, in exchange for restraint by workers and managers in the setting of wages and prices. The exchange-rate component eventually resulted in a system of preannounced daily mini-devaluations of an officially determined exchange rate, which increased the price of the dollar by fixed absolute amounts per day (and thus by decreasing percentage amounts).[28]

Liberalization and institutional reform in the financial sector were central components of Mexico's ongoing structural reforms. Financial liberalization proceeded in stages. The process began in November 1988, when quantitative limits on bankers' acceptances were eliminated. More extensive measures were adopted in April 1989, at which time controls on interest rates and maturities on traditional bank instruments were abolished, non-interest-bearing reserve requirements were replaced by a 30 percent liquidity ratio, restrictions on lending to the private sector were removed, and mandatory bank lending to the public sector at preferential interest rates was discontinued. In September 1991, the liquidity ratio was lowered on deposits outstanding at the end of August, and eliminated entirely for new deposits. A constitutional amendment

[28] From January 1989 to May 1990, the daily depreciation was one peso; from May 1990 to November 1990 it was 80 cents; from November 1990 to November 1991 it was 40 cents.

enacted in mid-1990 allowed full private ownership of banks. Other legislation during that year facilitated the formation of financial holding companies. This permitted several large banks that had been nationalized in September 1982 to be reprivatized. By July 1992, the last of eighteen previously government-owned banks had been privatized.

Mexico resumed access to voluntary capital inflows on a broad scale in the second half of 1989. Mexico's overall capital account surplus exceeded 8 percent of GDP over 1991–1993. Foreign direct investment led the surge in 1989 and remained important throughout the inflow episode, but portfolio flows increased rapidly over time and dwarfed FDI by 1991. Certificates of deposits in newly privatized Mexican banks and short-term peso-denominated government bonds (CETES), which foreigners had been permitted to acquire in January 1991, were important components of these short-term flows.

5.1.2 | Policy Responses to Capital Inflows, 1989–1993

Mexico's policy response to the surge in capital inflows was heavily influenced by the objective of sustaining the stabilization effort. The government adhered faithfully to its exchange-rate-based stabilization strategy, maintaining the downward trajectory of nominal depreciation for most of the period and attempting to stem domestic price-level increases through sterilized intervention in the foreign exchange market. Although the rate of inflation fell steadily, it continued to exceed the rate of depreciation of the peso throughout this period, resulting in mounting real appreciation. Toward the end of 1991, a more active exchange-rate policy was adopted in the form of a band. A floor for the value of the dollar was established at the value reached on November 11, and subsequent mini-devaluations were used to define a ceiling (see Chapter 7). The band would therefore widen over time at a rate determined by the daily rate of devaluation. However, at the time the band was introduced, the daily depreciation rate was lowered from 40 to 20 cents (that is, from 5 to 2.4 percent per year). Relative to previous policies, these measures both lowered the maximum rate of depreciation of the exchange rate and gave it more room to move in a downward direction. The new exchange-rate policy thus implied a more appreciated and potentially more variable nominal rate. While inflation had fallen into the single-digit range by 1993, it continued to exceed the rate of nominal depreciation after the adoption of the band, and the peso continued to appreciate in real terms.

The period 1989–1993 was characterized not only by a substantial cumulative appreciation of the peso, but also by a significant deterioration in the current account of the balance of payments in spite of steadily improving public sector finances. The deterioration of the current account thus arose from an excess of private investment over saving. While private saving exceeded investment by 1 percent of GDP in 1989, this situation had been reversed with a vengeance by 1992, in which year the private sector ran an overall deficit of 10.6 percent of GDP. Very little of this turnaround can be attributed

to an increase in private investment. The culprit was instead a decline in private saving amounting to 8.6 percent of GDP (from 13.6 to 5 percent) over this period. In spite of the gains achieved on the inflation front and its extensive structural reforms, Mexico did not register a sustained acceleration in economic growth when capital inflows surged. After rising above 4 percent in 1990 (the first full year of large inflows), growth slowed in each successive year. Thus, by 1994 the acceleration of economic growth had become an important concern for the Mexican authorities.

5.1.3 | The Balance-of-Payments Crisis

Mexico's balance-of-payments crisis in late 1994 was the outcome of an interaction among three sets of factors: First, the initial conditions at the beginning of 1994—in particular, slow growth, a fragile financial system, a persistently high current-account deficit, a reduction in the national saving rate, and a greatly appreciated real exchange rate; second, external and domest c shocks that materialized during the course of the year; and third, the nature of the policy responses to those shocks. In themselves, the initial conditions and shocks would not have been sufficient to trigger a balance-of-payments crisis, had the policy response been other than what it was. We suggest below that persistently slow growth, together with the fragility of the financial system, interacted with political factors to help explain why the Mexican authorities responded as they did to the policy challenge posed by the effects of adverse shocks in the context of the persistently high current-account deficit and appreciated real exchange rate.

5.1.3.1 | Initial Conditions

The Mexican peso appreciated strongly in real terms during 1988–1993 (as indicated above), and the current-account deficit reached a very high level which was not expected to subside in 1994. A second important feature of the pre-crisis Mexican experience is that the reforms instituted after 1985 did not result in a rapid and sustained resumption of economic growth in the short run. This can be attributed in part to tight monetary policy, designed to prevent capital inflows from fueling a monetary expansion that would undermine the government's inflation targets. Its effect was to keep domestic interest rates relatively high during 1992–1993. By 1993, the Mexican economy was in recession, with growth of less than 0.5 percent for the year as a whole, and negative growth during the second half. The third key aspect of the Mexican economic environment at the outset of the year was the fragile state of the financial system. The newly privatized and liberalized financial system experienced a period of very rapid expansion during 1991–1994, in spite of the prevailing high real interest rates. Loans grew at an average annual rate of 24 percent, far in excess of the average rate of growth of nominal GDP. In a context in which reserve requirements had been eliminated, the broad money multiplier, which had jumped in 1989 in the context of the initial steps

in liberalizing the financial system, continued to increase very rapidly over the period 1989–1993, more than tripling its 1988 value by 1993. Unfortunately, the quality of many of these loans was questionable. Although the 1990 Credit Institutions Law included provisions limiting the concentration of credit risk, ensuring the separation of interest between banking and other activities, and avoiding conflicts of interest for bank managers, past-due loan provisions grew at 27 percent per year over this time, and open loan exposure (past-due loans minus provisions) increased from 41 to 74 percent of bank equity, in a context in which underprovisioning may have been prevalent. Moreover, about 18 percent of bank deposits were denominated in U.S. dollars, making bank liabilities quite sensitive to exchange-rate changes. Thus, by 1994, the condition of Mexico's financial system was extremely fragile.

Real appreciation, slow growth, and fragility of the financial system may not have been unrelated. Dornbusch and Werner (1994), for instance, attributed Mexico's growth performance to the demand-reducing effects of real appreciation in the home goods sector, as well as to persistently high real interest rates—presumably reflecting, in Mexico's highly open capital markets, at least in part an expectation of future real depreciation. The combination of high real interest rates and low growth, in turn, is blamed for a deterioration in firms' balance sheets, and therefore those of banks as well.

5.1.3.2 | Shocks

Among the shocks that were relevant to Mexican economic performance and policy formulation in 1994 was one that occurred in November 1993—the approval of NAFTA legislation by the U.S. Congress. Because this issue was politically contentious in the United States, approval had not been a foregone conclusion, and indeed, Mexico lost substantial foreign exchange reserves ($5 billion) in October, as external creditors hedged against a failure of ratification. Together with Mexico's accession to GATT and membership in the OECD, the approval of NAFTA was viewed, probably not least by Mexican policymakers themselves, as an institutional commitment that would tend to be perceived by the private sector as "locking in" Mexico's economic reforms. The importance of this was to convince potential investors that the acquisition of *real* capital in Mexico was a good bet—in other words, that the option value attached to waiting rather than acquiring irreversible fixed assets in the Mexican economy had greatly diminished due to the substantial reduction in uncertainty concerning future policy reversals. The expectation triggered by the approval of NAFTA was that previous reforms would now begin to bear fruit in the form of a greatly accelerated pace of fixed investment.

Unfortunately, this favorable shock was followed by a succession of very unfavorable ones, both domestic and external. The most severe of these came in successive months during the first quarter of the year. The Chiapas uprising on January 1 created at worst the possibility of severe social conflict and at best the likelihood of fiscal and monetary relaxation to cope with economic

problems in the southern part of the country. This was followed in February by a very public change in the stance of U.S. monetary policy, in the form of a succession of interest rate increases engineered by the Fed beginning in that month and continuing throughout the year, resulting in a significant cumulative increase in six-month Treasury bill rates from February until the end of the year. The most severe shock, however, was the assassination of ruling-party presidential candidate Luis Colosio on March 23.

The economic effects of these shocks were predictable: higher rates of return in the United States and increased political and economic uncertainty in Mexico increased the risk-adjusted rates on return in U.S. relative to Mexican assets. The associated portfolio adjustments on the part of Mexican and foreign investors resulted in both price and quantity adjustments, taking several forms. First, three-month CETES, which had experienced gradually declining yields during the first quarter of 1994 (reaching a low of about 10 percent on an annual basis in February) experienced an increase in yield to the 17 to 18 percent range from March until the presidential elections in August. The CETES yield subsided thereafter, but remained in the 15 percent range until December. Second, Mexico began the year 1994 with foreign exchange reserves amounting to about U.S. $25 billion, and these peaked at about U.S. $29 billion during the first quarter, following the passage of NAFTA. Following a path similar to that of the CETES yield, however, the central bank's foreign exchange reserves dropped by U.S. $12 billion from February to April. Finally, the exchange rate, which had been roughly in the middle of its band at the end of 1993, jumped to the top of the band at the end of March and remained there.

Significantly, it appears that the events of the first quarter caused creditors to fear *both* devaluation and default on its obligations by the Mexican government. The former is evident in the sharp increase in the spread between peso-denominated CETES bonds and dollar-indexed Mexican government bonds (tesobonos). The latter is suggested both by the uptick in yields on Mexican Brady bonds as well as in the yield spread between tesobonos and U.S. Treasury bills of similar maturities. The suggestion is that, in spite of the fiscal accomplishments of the Mexican government and its low level of indebtedness, holders of Mexican Brady bonds and tesobonos did not appear to be convinced that their claims would continue to be serviced as scheduled in the event of a crisis.

5.1.3.3 | Policy Response

These reserve losses can be interpreted as the prelude to a full-blown speculative attack. As mentioned previously, in a stochastic setting, when the timing and magnitude of a prospective devaluation are uncertain, the period preceding the collapse of a fixed exchange rate is often preceded by sustained reserve losses and high domestic nominal interest rates. Possible responses to such an attack would be to defend the peg with tighter credit or to abandon it (by devaluing or adopting a different exchange-rate regime). If Mexican and foreign-interest-bearing assets had been considered perfect substitutes by private capital markets in 1994, tight credit may actually have reduced nominal interest rates in Mexico, due to the elimination of devaluation expectations and exchange-rate risk, because the sustainability of the peg would have been enhanced. With sufficient inertia in the inflation process, real domestic interest rates would have fallen as well. With imperfect substitutability, however, tight credit would have raised real interest rates in Mexico, slowing the growth of interest-sensitive components of aggregate demand and possibly causing a contraction in supply (by increasing the costs of financing working capital). The effect would have been a deepening of the recession, with particularly negative effects on investment, possibly some upward pressure on the price level emanating from the supply side of the economy, and consequent stress on the financial system. Alternatively, abandoning the peg would have represented a major revision of the anti-inflation strategy, and in particular the government would have been perceived as reneging on the Solidarity Pact by engineering an inflationary surprise on workers and firms.

These options would have proven unpalatable to any government in normal times, but were even more so in the context of a presidential election whose results were uncertain and in which a defeat of the governing party would have been of cataclysmic proportion, signifying the end of six decades of one-party rule. Caught between two undesirable options with unpleasant political consequences, the government responded to the events of the first quarter in two ways. First, on monetary policy, it chose to stay the course, holding to its exchange-rate path and sterilizing foreign exchange outflows by doing the reverse of what it had previously done to offset the monetary effects of inflows—that is, expanding domestic credit. The evidence suggests that the reaction function of the monetary authorities—featuring specifically the sterilization of changes in gross reserves—was stable over the course of 1994 (see Kamin and Rogers, 1996). During 1994, sterilization took the form of a substantial increase in lending activities by the development banks, financed by credit from the central bank. Second, an additional component of the policy response was in the area of debt management. The fiscal implications of the emergence of exchange-risk premia in domestic interest rates were avoided by replacing maturing CETES with short-term dollar-indexed debt (tesobonos), which paid much lower interest rates. Because the CETES themselves were relatively short-term, the transformation in the structure of the debt was very rapid. The change in the currency composition and maturity of debt in the direction of dollar indexation and short maturities after the first quarter proved to be dramatic, resulting in an increase of tesobonos in domestic debt from 5 percent at the beginning of the year to 55 percent by its end.

One justification for this strategy was based on the hope that a post-NAFTA or post-election investment boom, coupled with long-awaited improvements in productivity performance, would generate a resurgence of

economic growth that would validate the real exchange rate and render the current-account deficit sustainable. The plausibility of this view was enhanced by strong growth of non-oil exports and the large share of capital goods in Mexican imports.

5.1.3.4 | The Crisis

The behavior of capital flows, as well as the premia for exchange-rate and default risk built into Mexican instruments over the course of 1994, indicate that speculative pressures were building up over the course of the year. The obviously unsustainable value of the current account made some form of adjustment inevitable—only the form and timing were at issue. Some form of expenditure reduction and/or switching would be needed if a post-NAFTA growth boom did not materialize as hoped. The key point is that the returns on assets invested in Mexico—both by foreign and domestic residents—would depend on what form that adjustment took. Assuming no outright repudiation of debt, some combination of fiscal and/or monetary contraction and nominal devaluation would have been required to produce the requisite adjustment. From the perspective of creditors holding peso-denominated assets, the most dangerous of these is obviously the last, because it involves a capital levy for peso creditors with consumption baskets denominated at least partially in dollars. The enormous fiscal adjustment already undertaken in Mexico, the threat of financial crisis that would be posed by a severe domestic recession, and the large cumulative real appreciation of the peso, all raised the probability that adjustment would eventually feature a component of nominal devaluation. Moreover, because the costs of devaluing in terms of foregone credibility for the authorities were not likely to be very sensitive to the size of the ultimate devaluation, and because the perceived degree of overvaluation was large, it was at least possible that the magnitude of the eventual devaluation would be large as well.

The critical issue concerning the timing of the crisis was the change in political administration following the presidential elections held in August. Not only was the outcome of the elections in question, but even if the ruling party were to return to power, the commitment of the new administration to staying the course with the disinflation strategy—a strategy closely associated with the Salinas administration and Finance Minister Aspe—was unknown. A scenario that could not be ruled out even in the event of a return to power by the ruling party was that the outgoing Salinas administration would implement the devaluation between the elections in August and the accession to power of the Zedillo administration in December, thereby absorbing the political costs of the change in course and presenting the new administration with the opportunity of beginning its term with a clean slate. Given the climate of uncertainty that prevailed among Mexico's international creditors, any signal that the new administration was likely to consider a revised exchange-rate policy was likely to trigger a speculative attack. Several such signals were indeed sent—perhaps inadvertently—by both administrations over the course of the year.

The evolution of both fiscal and exchange-rate policies during 1994 suggested that the outgoing administration was more prepared to consider an adjustment in the nominal exchange rate than a further round of fiscal contraction in designing an adjustment strategy. On the one hand, the substantial capital outflows during the course of the year did not trigger an adjustment in the primary surplus. On the other, the exchange rate was allowed to depreciate to the top of its band during the second quarter, representing a nominal depreciation of about 8 percent against the U.S. dollar over this period. As indicated previously, the peso then spent most of the rest of the year near the top of its fluctuation band.

Regarding the new administration, a first indication of its intentions may have come when the new cabinet was named and Finance Minister Aspe was replaced by Jaime Serra-Puche, the former Trade Minister who had negotiated the NAFTA agreement with United States. The new minister could reasonably have been expected to give greater weight to the allocative role of the exchange rate, as opposed to its role as nominal anchor, than his predecessor.

The result of these events was further reserve losses between August and December. By the beginning of December, the stock of reserves had fallen to the $10 billion range, and a vulnerability index motivated by the recent literature on exchange-rate crises, calculated as the ratio of the stock of net liquid foreign-currency assets (foreign exchange reserves minus tesobonos outstanding) to the monetary base, had fallen to the lowest levels reached during the 1990s.[29] On December 20, the upper level of the Mexican exchange-rate band was increased by 15 percent. This was perceived by the markets as too little, too late. The result, consequently, was to trigger the final speculative attack. After two days of rapid reserve losses, the peso was forced to float.

5.2 | The Thai Baht Crisis (July 1997)

The Mexican currency crisis was the outcome of a complex set of circumstances: initial conditions creating vulnerability to speculative attack, adverse shocks, and policy choices made among competing domestic objectives in the midst of an election year. The key ingredients, however, were an overvalued exchange rate and a fragile financial system. The former implied the necessity of adjustment, while the latter severely circumscribed the form that adjustment could take by magnifying the likely domestic macroeconomic costs of a traditional high-interest-rate defense of the exchange-rate peg. Unfortunately, these ingredients did not prove to be *sui generis*. Shortly after the Mexican

[29] An alternative vulnerability index has been proposed by Calvo and Mendoza (1996). This index is essentially an indicator of the liquidity position of a central bank that guarantees the value of the currency as well as the liabilities of the banking system. It consists of the relative size of the central bank liquid foreign-currency assets (reserves) to its potential foreign-currency liabilities, which under these circumstances consist of the entire stock of broad money.

crisis, a similar set of circumstances interacted to produce a similar result in Thailand.

5.2.1 | Background

As documented in the previous chapter, capital inflows to Southeast Asia increased sharply in the early 1990s, with short-term inflows playing an increasingly larger role over time. Rising inflation and increasing current-account deficits increased concerns about macroeconomic overheating throughout the region. The domestic macroeconomic policy response consisted of the implementation of tight monetary policies, which sustained domestic interest rates at relatively high levels. Because countries in the region continued to pursue nominal exchange-rate targets (despite occasional official statements to the contrary), tight money essentially meant the sterilization of balance-of-payments surpluses, conducted through a variety of means. In the case of Thailand in particular, the intensity of sterilization was increased in 1993, when the country experienced an upsurge in private capital inflows associated with the establishment of the Bangkok International Banking Facility (BIBF). One implication of a policy mix relying so heavily on monetary policy to restrain the expansion of aggregate demand was an intensification of short-term inflows intermediated through the domestic financial system.[30]

The demand for loans was sustained despite relatively high domestic real interest rates as the result of the emergence of asset price inflation associated with rapid and poorly supervised financial expansion in the first half of the 1990s. The legacy of this situation, however, was a financial system with borrowers whose creditworthiness and the value of whose collateral was heavily dependent on inflated asset values. This made the net worth of these institutions vulnerable to a downward correction of domestic asset prices. Such a correction could come about in two ways: through a negative reassessment of the earning streams associated with these assets, or through an increase in the discount rates applied to these earning streams. The second of these began to play a role by late 1995, as the sharp monetary tightening continued to raise domestic interest rates throughout the region. Indeed, due to high interest rates, stock market performance in the region as a whole turned poor in 1994–1995.

The combination of inappropriate financial liberalization, resulting in excessive intermediation, and inadequate fiscal flexibility, resulting in disproportionate reliance on tight money to combat overheating, put strains on domestic asset values and increased the stock of short-term external liabilities. In Thailand, as in Mexico, these policy mistakes did not imply that a crisis was inevitable (that is, they did not constitute *sufficient* conditions for a crisis), but they did create a state of vulnerability that was centered on the financial sector. Nonetheless, in the absence of negative shocks, a crisis would have been avoidable, or at least postponable. Unfortunately, a third policy mistake, in the area of exchange-rate management, pushed vulnerability to the breaking point.

[30] For cross-country evidence on the links betwen sterilization and the magnitude of short-term inflows, see Montiel and Reinhart (1998).

The maintenance of a competitive real exchange rate had been a cornerstone of development strategy in Southeast Asia since the mid-1980s. One manifestation of macroeconomic overheating in Thailand during 1994–1995 was that the domestic rate of inflation, while relatively low by Latin American standards, remained higher than those of the country's trading partners. In the absence of changes in real exchange-rate fundamentals, failing to offset this inflation differential by nominal depreciation would in itself have implied a real exchange-rate appreciation and consequent loss of competitiveness. This combination of financial sector fragility, fiscal rigidity, and real exchange-rate appreciation recall the ingredients of the Mexican crisis of December 1994.

5.2.2 | Triggering Events

Sufficient conditions for a full-blown exchange-rate crisis materialized in Thailand in the form of the emergence of adverse external conditions. These had medium-term as well as short-run components.

5.2.2.1 | Medium-Term Developments

A key medium-term development was that Thailand seems to have been losing external competitiveness during the first half of the decade of the nineties. The key factor in this regard was the emergence of China as a major exporter of labor-intensive manufactured goods. Because this development implies that, to remain competitive, Thailand would have had to export at lower prices, it is equivalent in its effect on the long-run equilibrium real exchange rate to a terms-of-trade deterioration. The implication is that the long-run equilibrium real exchange rate would depreciate. Given the mild appreciation of the actual bilateral real exchange rate against the U.S. dollar, this implies a growing gap between the actual and long-run equilibrium real exchange rates. Indeed, by 1995, an overvaluation of the Thai baht amounting to approximately 30 percent had emerged.

5.2.2.2 | Short-Run Developments

The directly observable shock that preceded the Thai currency crisis was a collapse in export growth. Poor export performance materialized throughout the Southeast Asian region in 1996. Asian export growth slowed markedly in the first half of 1996 (in dollar terms, 7 percent growth compared to 20 percent in 1995), and despite expectations to the contrary, failed to recover as the year wore on. The implications were twofold. First, poor export growth implied reduced GDP growth through standard channels. This reduced the income streams expected to be associated with domestic assets, and dampened domestic asset values through this channel, which reinforced the negative impact of high domestic interest rates. Second, poor export growth

also introduced an element of noise into the medium-term competitiveness calculations. To the extent that the export slowdown may have reflected a loss of competitiveness, it suggested that the gap between the actual and equilibrium real exchange rates may have been larger than had earlier been imagined.

Why did export growth slow? Possible sources of loss of competitiveness include those already mentioned—that is, the inflationary effects of overheating (not compensated by nominal exchange-rate depreciation) and growth in Chinese export capacity. Two other factors also contributed, however. First, the U.S. dollar appreciated sharply against the Japanese yen after mid-1995 (by 35 percent as of August 1996 relative to the dollar's 1995 trough). Given the role of Japan in the trade patterns of Southeast Asian countries, this implied an appreciation of the actual REER in these countries, and a further widening of the gap between actual and equilibrium real exchange rates after mid-1995. Second, the final factor was a collapse in semiconductor prices blamed by the press on worldwide overcapacity and a weak market for personal computers, itself due to poor growth performance in Japan and Western Europe. This may have been a transitory real shock, which does not in itself affect the equilibrium real exchange rate. However, as shown in Chapter 10, the classic textbook response to such a shock for the objective of stabilizing aggregate demand is a temporary exchange-rate depreciation. The contribution of this shock to the crisis may therefore have come in the form of increasing the perceived likelihood of a devaluation.

The upshot is that negative shocks during 1996 had two effects. On the one hand, they widened the perceived gap between the actual and equilibrium values of the REER, through an appreciation of the actual REER as well as through a depreciation of the perceived equilibrium REER. On the other, they increased the vulnerability of financial sectors by depressing asset values and weakening the balance sheets of financial institutions in the region.

In other words, they culminated in the emergence of vulnerability very similar to that of the Mexican case analyzed previously. The emergence of apparent misalignments implied the perception in financial markets that nominal exchange-rate adjustments might be forthcoming, while fragility in the financial sector suggested that the costs of resisting such a misalignment, under pressure from speculation, would likely be perceived by the authorities in the region as prohibitively high. These two factors made nominal exchange-rate adjustments inevitable. How the adjustment came about would depend on how the situation was managed by the authorities.

5.2.3 | Emergence and Management of the Crisis

Given the perceived gap between the actual and equilibrium real exchange rates, and the presence of factors arguing for a transitory overdepreciation of the actual exchange rate, it became prudent for agents, in the normal course of business, to hedge against the possibility of devaluation by moving

assets out of baht. Because this fact would in itself magnify the likelihood of an exchange-rate movement (by consuming the central bank's reserves), other agents would have the opportunity to make money by borrowing baht. Whether such transactions would prove profitable ex ante depended on markets' expectations of the authorities' resolve in maintaining the value of the currency by increasing the cost of those transactions through increases in domestic interest rates. As in Mexico, this is where the vulnerability of the domestic financial system and the domestic economic slowdown play key roles. Because high interest rates would have impaired both the balance sheets and cash flows of domestic financial institutions, market participants would have perceived that fighting off a speculative attack through this traditional method would have been judged too costly by the authorities, particularly in light of the region's traditional commitment to the competitiveness objective.

By mid-1996, the region's export problems were beginning to receive widespread attention. Dr. Mahathir Mohammad, the Prime Minister of Malaysia, warned in August of import controls if a voluntary scheme failed to reduce his country's trade deficit. In Korea, exports fell during the month of July for the first time in forty two months. The first hints of currency problems in Thailand emerged during late July and early August 1996, triggered by worries over export competitiveness in the region. Following a bleak report on economic prospects issued by the Bank of Thailand, the central bank was forced to spend U.S. $1 billion to support the baht.[31,32] By the end of the month, though, the Bank still possessed U.S. $39.4 billion in foreign exchange reserves. Nevertheless, in September, Moody's downgraded Thailand's short-term foreign debt, noting financial-sector problems and the rapid accumulation of foreign debt during 1995 (amounting to a 40.7 percent increase in the stock of debt outstanding over the course of the year, to a year-end value of U.S. $41.1 billion).

While Mexico's currency crisis played itself out during a ten-month period in 1994, the crisis in Thailand took almost a full year (August 1996 to July 1997) before it culminated in the abandonment of the exchange-rate parity. Over the course of that year, news on export performance, economic growth, and financial-sector problems grew progressively worse, and outflow episodes became progressively more severe. As growth slowed and domestic interest rates were maintained at high levels to defend the currency, the stock market fell, losing 35 percent of its value during 1996. Increases in the perceived risk of default led to a drop in bank lending and a largely voluntary accumulation

[31] The Bank of Thailand revised 1996 projected real GDP growth from the 8.3 percent forecast earlier to 7.8 percent, and revised projected export growth to 10.2 percent, compared to 17.4 percent projected earlier and to 23.6 percent in 1995.

[32] Earlier blips had affected the Indonesian rupiah (but for idiosyncratic reasons—that is, when a medical trip abroad by President Suharto fueled concerns over political instability), and the Malaysian ringgit in early January 1996, when information about the size of Malaysia's current-account deficit became available.

of excess liquid assets by the banking system (Agénor, Aizenman, and Hoffmaister, 2004). Unfortunately, the government's handling of the crisis left much to be desired from its outbreak until the final abandonment of the peg on July 2, 1997 and beyond. Key mistakes were made in both areas of vulnerability: exchange-rate policies and policies toward the financial sector.

5.2.3.1 | Exchange-Rate Policy

The government's biggest mistake was to attempt to hold the nominal value of the baht for almost a year. Its adherence to the exchange-rate peg in the context of devaluation expectations resulted in large capital outflows and very high domestic interest rates which, through their effects on the government's liquidity position and the balance sheet of the financial system, together magnified the uncertainty and instability that resulted after the baht was eventually floated. Despite the pressure on the currency in mid-1996 and again in February 1997, at the end of March 1997, the Bank of Thailand continued to report foreign exchange reserves of U.S. $38 billion, almost unchanged from the July 1996 level. By the time the baht was floated in July 1997, reserves had officially fallen only to U.S. $33 billion. It later became apparent, however, that reserves were maintained through large swap transactions, leaving the Bank with a stock of future dollar liabilities in excess of U.S. $23 billion after the flotation of the currency. The loss of liquidity created uncertainty in the market after the baht was floated as to whether the country would be able to meet its large short-term external obligations in the event that private agents did not roll over a significant portion of these, and this perceived vulnerability to a liquidity crisis undermined the value of the currency after the float.

Moreover, despite its actual adherence to a fixed value for the baht for almost a year, the government increased the cost of this policy for itself by sending clear signals that its commitment to the exchange-rate peg was not firm. In January 1997, for example, the government announced its intention to reevaluate the exchange-rate regime when the economy regained strength, fully six months before the regime was actually modified.

5.2.3.2 | Financial-Sector Policy

Given the exchange-rate policy, the second key mistake was to postpone the resolution of the problems of the financial system. The government initially (during most of 1996) denied the vulnerability of the country's fifteen commercial banks and ninety finance companies. However, as mentioned above, maintaining the fixed exchange rate required very high domestic interest rates, which in turn continued to undermine the value of assets held by the financial system that the government was otherwise trying to support (see below). The effect was to jeopardize the solvency both of finance houses and banks, which added to the stock of nonperforming assets in the financial

sector and to the eventual cost of resolving the sector's difficulties.[33] The increase in this cumulative cost impaired the government's fiscal position, and this unresolved liability overhang was a second source of uncertainty which increased instability in the period after the currency was ultimately allowed to float, as well as magnifying the ultimate fiscal burden associated with the crisis.

Much of the policy story from mid-1996 to mid-1997 in Thailand concerns the evolution of policies toward the financial system. Because this was the key area of vulnerability, the credibility of the exchange-rate peg and consequently implications both for capital outflows and for domestic interest rates depended on policies directed to the financial sector.

As the end of 1996 approached, financial-sector share prices reflected an extreme lack of confidence on the part of the market. The government's initial policy response was inadequate, consisting of a regulation imposed in December requiring only banks (and not the more exposed finance companies) to disclose the extent of their bad loans, and the adoption in January 1997 of a series of measures seeking to artificially prop up property values. The latter essentially represented an attempt to avoid the problem by seeking to sustain the value of the assets held by the domestic financial system, rather than recognizing and allocating the losses of bank and finance company capital, and recapitalizing the financial sector under a more stringent supervisory and regulatory regime. In January 1997, the Cabinet announced the creation of a government fund to purchase a portion of their bad property debt from finance companies, financed through the sale of bonds with government guarantee. The measure backfired, both because it signaled the government's intention to bail out some of these companies, and because it inadvertently revealed policy disarray within the government—despite the Cabinet's announcement that the Central Bank would contribute to the fund, the latter publicly balked at doing so. By late February 1997, depositors engaged in a run on Thai finance companies, transferring deposits to the relatively safer banks (approximately 10 percent of bank loans were to property developers, compared to 25 percent for finance companies) and moving money abroad. Not coincidentally, renewed pressure on the baht emerged in February. The Bank of Thailand responded by tightening monetary policy. High interest rates resulted in a succession of financial crises triggered by falling property values. The central bank, engaged in its lender-of-last-resort function, extended credits to these institutions which were later estimated to total U.S. $15.7 billion. Nonetheless, the finance company liquidity crisis culminated in the failure of Finance One, the country's largest finance company, despite its relatively small stock of bad loans in late February, while in April the

[33] In March 1997, Standard and Poor's Rating Service estimated the cost to the government of bailing out insolvent institutions at 6 percent of GDP, while by August that figure had increased to 12 to 15 percent of GDP.

government took responsibility for the Bangkok Bank of Commerce, after it ran up $2 billion of bad debt. These bad debts were absorbed by the government.

In the wake of the difficulties of Finance One, stringent provisioning requirements were imposed on all financial institutions, and ten small finance companies were required to increase their capital. Nonetheless, public disclosure of the magnitude of the bad loan portfolio among finance companies was not required.

Further measures were adopted in May, but these proved to be of a stopgap nature. Capital controls were imposed in the form of instructions to local banks not to sell baht to foreigners in the swap market. The intention was to fight off speculation by discouraging short positions in the baht in the spot market offset by long positions in the forward market. Expenditure cuts were announced to offset shortfalls in tax revenue due to the economic slowdown, indicating that the government was sacrificing the use even of automatic stabilizers in its attempt to shore up the currency. Finally, a bank-financed fund was set up to buttress the stock market.

Finance Minister Amnuay Viravan resigned on June 18, complaining of political interference, and was replaced by Mr. Thanong Bidaya, former president of a large commercial bank which had itself been among the country's most troubled. Despite market concerns that these links would lead to easing of the provisioning and capital adequacy regulations imposed earlier, the government actually began to signal a tougher stance toward the financial sector in late June. Merger laws to accommodate the takeover of companies in difficulties were eased, and sixteen finance companies were ordered to suspend operations and seek merger partners within thirty days. The government indicated that troubled finance companies that failed to merge would be allowed to go under. This suggested for the first time that, while the government's implicit guarantee of bank deposits continued to hold, shareholders in the finance companies would not be bailed out.

Unfortunately, the measures adopted toward the financial sector in late June proved to be too little, too late. The central bank announced in June that its gross foreign currency reserves had fallen to U.S. $33.3 billion in the course of five straight months of balance-of-payments deficits, not including short-term foreign exchange liabilities in the form of swaps undertaken to support the baht. The baht was finally floated on July 2. In the first day, it fell by over 16 percent, and in a month's time, it depreciated by over 25 percent. Despite the float, however, the country's problems were not over. The shortage of liquidity and the accumulation of nonperforming loans in the financial sector left a significant overhang of uncertainty, and the authorities intervened to seek to avoid excessive depreciation of the baht. Rather than moving toward lower domestic interest rates, on the occasion of the float the central bank raised its discount rate by two percentage points. Despite the government's insistence as late as July 7 that it required no IMF assistance, the uncertainty surrounding the liquidity and fiscal problems led it to begin negotiations with the Fund on July 28, and a program was agreed upon one week later.

5.3 | Brazil's Real Crisis (January 1999)

Faced with triple-digit inflation in the early 1990s, in mid-1994 Brazil launched an ambitious stabilization program, the Real Plan (see Chapter 11). The plan was successful in rapidly achieving single-digit inflation. However, stabilization was accompanied by strong domestic demand growth and an appreciation of the real exchange rate, which forced the authorities to keep real interest rates at relatively high levels.

In turn, by increasing debt-service payments, high interest rates contributed to a sharp deterioration in fiscal accounts. The conventional fiscal deficit increased from about 6 percent of GDP in 1994 to more than 10 percent in 1998. The operational deficit (that is, the deficit excluding the impact of inflation on interest payments, as discussed in Chapter 4) rose from an average of 2.4 percent of GDP in 1994–1996 to nearly 8 percent in 1998, whereas the primary surplus fell from 2 percent of GDP in 1994–1996 to approximate balance in 1998. As a result, the stock of domestic public debt grew rapidly between 1995 and 1998.[34] At the same time, the significant appreciation of the real exchange rate in the initial stages of the plan contributed to a widening current-account deficit.

Growing fiscal and external imbalances led to a first wave of speculative pressures in late 1997, following the Asia crisis. The authorities responded with a sharp tightening of monetary policy and the announcement of fiscal measures aimed at reducing the deficit by the equivalent of 2 percent of GDP in 1998. High interest rates and a relaxation of capital account restrictions led to renewed inflows of capital in early to mid-1998, which helped rebuild international reserves.

However, fiscal adjustment proved difficult to achieve, because the key measures that were to be implemented required congressional approval. In December 1997, the government suffered a damaging political defeat when its civil service pension reform proposals were defeated in Congress. The persistence of fiscal weaknesses and growing perceptions of external vulnerability, together with the general adverse effects of the Russian default in August 1998 on private capital flows to developing countries, led to renewed speculative pressures on the exchange rate in the second half of 1998. The

[34] As noted by Bevilaqua and Garcia (2000), although much of the surge in debt was the combined result of the government's deficit and the high interest rates needed to defend the (overvalued) exchange rate, part of it was also due to government's previously hidden liabilities—some of which came to light when state enterprises were privatized. See Giambiagi and Ronci (2004) for a more detailed discussion of the dynamics of public debt in Brazil during the period 1995–1998.

authorities responded by intervening heavily in the foreign exchange market and by increasing interest rates sharply.

After the October 1998 presidential elections, a support package of about $44.5 billion (led by the International Monetary Fund) was announced. Financial support was made conditional on extensive fiscal adjustment. But the agreement with the IMF and the first disbursement in early December improved the outlook only marginally. Spreads on Brazil's international debt remained high and capital outflows continued. Congress refused to approve a number of crucial fiscal measures, casting doubt on the effectiveness of fiscal restraint and the ability of the authorities to achieve the fiscal targets.

The practical debt moratorium announced by the state of Minas Gerais in early 1999 increased pressure on the exchange-rate regime.[35] In the first week of 1999, the country lost U.S. $0.5 billion, reducing total reserves to around U.S. $38 billion, compared with U.S. $70 billion at the end of July 1998. The weakening of reserves made the position of central bank governor Gustavo Franco untenable, and he resigned on January 13, 1999. That same day, net capital outflows reached U.S. $0.7–0.8 billion, following an outflow of U.S. $1.2 billion the day before.

In an attempt to lessen pressure on reserves and lay the groundwork for a loosening of monetary policy, the government attempted to implement a limited and controlled devaluation. The *real*, which had been allowed to fluctuate between a band of 1.12 to 1.22 to the U.S. dollar, was allowed on January 13 to trade between 1.20 and 1.32, with greater scope for fluctuation within the new band. Markets responded immediately to the revised arrangements, with the *real* trading near the floor of its new band at 1.31 to the U.S. dollar. This amounted to a 9 percent nominal devaluation of the currency in relation to its closing value on January 12.

However, this did little to calm speculative pressures, as fears about a possible debt default grew. Public debt prior to the crisis had a relatively short maturity (about 11 months), and consisted to a large extent of floating-rate instruments, thereby creating significant exposure to abrupt changes in short-term interest rates. Moreover, at the end of 1998, the U.S. dollar-denominated and U.S. dollar-indexed federal debt represented about 28 percent of total debt (Bevilaqua and Garcia, 2000). The large stock of foreign exchange–denominated bonds and floating-rate Treasury bills led to the perception of vulnerability of the government deficit to devaluation and high interest rates, and the fear of potentially explosive dynamics of the domestic public debt-to-GDP ratio, should interest rates and debt-servicing requirements fail to come down.

[35] In Brazil, state governors are responsible for a large proportion of total government spending. In early January, Itamar Franco—the governor of the state of Minas Gerais and then a staunch opponent of President Cardoso—announced a 90-day moratorium on the servicing of his state's debts to the federal government. Following Franco's lead, a number of other state governors, including those of Rio de Janeiro and Rio Grande do Sul, announced that they intended to renegotiate their debts with the federal government. Although some state governors expressed their support for Cardoso's administration, the confrontation weakened confidence.

Sustained capital outflows continued, and on January 15 the *real* was floated. Fears of unstable debt dynamics and a vicious circle of continuing downward pressure on the currency and upward pressure on interest rates led to a sustained weakening of the currency, and the real depreciated by about 40 percent in the two ensuing months.

5.4 | Argentina's Peso Crisis (January 2002)

5.4.1 | Background

Argentina had a turbulent economic history during the 1980s, marked by repeated bouts of nominal instability that were associated with poor performance in the real economy. For the decade as a whole, real GDP peaked in 1980. It had declined by 10 percent by 1985, accompanied by severe inflation. Under the heterodox Austral Plan (see Chapter 11), it recovered almost to its peak by 1987. But an inability to exert fiscal discipline led to the collapse of the plan, resulting in two bouts of hyperinflation at the end of the decade. GDP fell to 10 percent below its 1980 level by 1990, in the midst of a hyperinflation of 4000 percent per year. At the end of this period, prices were rising by 200 percent per month (tripling every month). Overall, income per capita contracted by 1 percent per year from 1976 to 1989.

Carlos Menem took office as Argentine president in 1989. His administration's initial attempts at stabilization proved to be unsuccessful, culminating at the end of 1990 in renewed high inflation and nominal exchange-rate depreciation, as well as bank runs. This caused the Menem administration to opt for a new strategy that represented a drastic break from the past under Finance Minister Domingo Cavallo, who was appointed in January 1991. Cavallo implemented an orthodox macroeconomic program featuring extensive privatization of state enterprises, trade liberalization, measures to strengthen the domestic banking system, and macroeconomic stabilization. The centerpiece of the macroeconomic stabilization strategy was the Convertibility Plan, implemented in April 1991 (Chapter 11). It consisted of the creation of a currency board, with the exchange rate set at the fixed value of 10,000 australes per dollar (changed to one Argentine peso per dollar under the monetary reform of 1992). The stabilization plan also featured fiscal reforms, the elimination of wage indexation, and granting legal tender status to the U.S. dollar.

In many ways, Argentina was not an ideal candidate for a currency board from an optimal currency area perspective (see De la Torre et al., 2003), and this fact played an important role in the evolution of the crisis that ultimately brought down the currency board. The country is subject to shocks that are asymmetric with those experienced by the United States

(specifically, as a primary producer, Argentina is subject to important terms-of-trade shocks), its trade is dominated by countries whose currencies float relative to the U.S. dollar (Argentina's trade is primarily with Europe and Brazil, rather than the United States), it is a relatively closed economy for which correspondingly large real exchange-rate changes are required to adjust the trade balance, and it has relatively rigid domestic labor market institutions, making domestic wages and prices relatively inflexible. The latter places a premium on nominal exchange-rate flexibility. However, optimal currency area criteria were dwarfed in importance in 1991 by the lack of nominal credibility that had characterized the country's recent history. The dominant force driving the adoption of the currency board arrangement was the desire to import that credibility and finally stabilize the domestic price level.

The stabilization proved to be extremely successful in both nominal and real terms. Inflation was reduced to single digits by 1993, and real GDP increased by 28 percent from 1990 to 1993. As the result of the effects of the 1989–1991 inflation on the real value of domestic debt, a Brady Plan debt restructuring, the rapid growth of the economy, and the relatively tight fiscal policy maintained during the early part of the decade, the ratio of public debt to GDP was reduced from 70 percent in 1989 to 29 percent by 1993. At the same time, the ratio of banking system deposits to GDP, a measure of financial deepening, increased steadily. Not surprisingly, Carlos Menem was easily reelected to a second five-year term in 1994.

However, the credibility of the currency board arrangement proved difficult to establish, and in 1995 Argentina was severely affected by the Mexican crisis (this spillover was known as the Tequila effect). Reserves fled the country, and capital outflows amounted to 5 percent of GDP in the first quarter of 1995. Domestic interest rates rose sharply, from about 10 percent on peso deposits to 15 percent. The banking system lost nearly one-third of its deposits, real GDP contracted, and unemployment climbed to over 16 percent of the labor force. The government responded with a fiscal contraction to restore confidence, a lowering of bank reserve requirements to enhance bank liquidity, and a reform of the banking system, all in the context of an IMF program. In addition, an external credit line was negotiated with international banks.[36] The currency board held, and capital inflows returned in mid-year, rising to nearly 10 percent of GDP by the end of the year. The new monetary arrangement proved to be more robust than financial markets had feared.

Roque Fernandez took over from Domingo Cavallo as Finance Minister in 1996, and oversaw a brisk resumption of economic activity in Argentina. Real GDP growth was 4 percent in 1996 and nearly 7 percent in 1997. Overall, growth averaged 4.4 percent from 1993 to 1998, despite the sharp Tequila

[36] The reform of the banking system involved bank mergers and "internationalization," and was quite successful, leaving Argentina ranked second among emerging market countries in the quality of its bank regulatory environment by 1998.

recession in 1995, and the GDP deflator increased by a cumulative amount of only 3 percent over that time. However, public sector debt grew rapidly, and unemployment remained high. During this time, the country was under the almost continuous tutelage of the IMF, with Fund programs in place for most the 1990s. Though the Fund was initially skeptical of the currency board arrangement, after the Tequila crisis it supported the authorities' decision to sustain the peg (Mussa, and Powell, 2002).

5.4.2 | The Buildup of Vulnerability

The period from 1994 to 1998 was a critical one in setting the stage for the crisis that ultimately befell Argentina at the end of 2001. Specifically, during these years two sources of vulnerability accumulated that made the system highly vulnerable to the series of shocks that hit the economy from 1998 on, in the sense that the combination of those shocks with the limited adjustment options available under the currency board greatly increased the probability of a crisis. The sources of vulnerability consisted of a rapid buildup of public sector debt and the accumulation of currency mismatches in the balance sheets of both the government and domestic firms, both of which in turn increased the vulnerability of the domestic banking sector.

5.4.2.1 | Public Sector Debt

As mentioned above, by 1994 Argentina had a relatively low ratio of public debt to GDP, amounting to about 29 percent. Although the economy exhibited rapid growth on average from 1993 to 1998, public debt started growing in 1994, and by 2001 the ratio of public sector debt to GDP had increased to 54 percent. Loose fiscal policy in Menem's second term has been blamed by some observers for the accumulation of this debt. Indeed, though the ratio of the fiscal deficit to GDP was 1 percent during the first half of the decade, it increased to 3 percent in the second half. Although the Argentine economy recovered from the Tequila crisis more rapidly than anticipated in the Fund programs in which it participated during these years, it actually ran slightly higher deficits than envisaged in those programs. Mussa (2002) has argued that the failure of the IMF to put more pressure on Argentina to reduce its fiscal deficits in the post-Tequila period was one of the most serious errors of Fund policy in the country.

However, as shown by Hausmann and Velasco (2002), Argentina's cumulative fiscal deficit from 1994 to the end of the decade falls far short of accounting for the total increase in the size of the debt. Of the cumulative increase in gross debt of U.S. $47.7 billion from December 1994 to December 2000, purchases of liquid assets (collateral and cash) accounted for U.S. $11.7 billion, the official recognition of previously existing debt, for U.S. $16.4 billion, and the cumulative fiscal deficit, for U.S. $21.8 billion. Moreover, the cumulative fiscal deficit was more than accounted for by the cumulative deficit of the Social Security system, arising from the transition

from a pay-as-you-go to a fully funded system that was implemented in 1994. This reform diverted Social Security revenues from the government's budget into the assets of private pension funds. Excluding Social Security and the provinces (which ran primary deficits in the vicinity of 1 percent of GDP over the period), the rest of the national government ran a primary surplus during the entire 1993–2001 period, and this surplus averaged some 3 percent of GDP even during the recession years 1998–2001. How, then, to account for the increased overall deficits mentioned in the previous paragraph? Part of the answer is that the increase reflected the larger deficits of the Social Security administration. The rest of it, however, is that deficits increased because of sharp increases in interest payments, as the government's debt-service obligations increased from less than 1 percent of GDP in 1993 to over 4 percent of GDP by 2001. Finally, the rise in the debt/GDP ratio from 1998 to 2000 was largely due to the recession, as nominal GDP contracted by some 5 percent during this period.

These observations suggest that the increase in Argentina's debt to GDP ratio was not due to fiscal profligacy. Nonetheless, this does not absolve fiscal problems from a role in the ultimate debt accumulation outcome. The reason is that whatever the source of the debt accumulation, fiscal policy ultimately bears responsibility for keeping the public debt below a threshold beyond which the government would be unable to service the debt in the event of unfavorable shocks that have a reasonable likelihood of occurring. It is obviously clear ex post that the Argentine government failed to do this; however, two considerations suggest that the rapid accumulation of public debt should also have been perceived as a danger signal ex ante.

First, reflecting Argentina's relatively closed economy, debt in 2001 was 423 percent of exports. This matters because the small size of the traded goods sector affects the elasticity of the trade balance with respect to the exchange rate, and thus the size of the movement in the exchange rate that would be necessary to generate the dollars required to service dollar debt (see Calvo, et al., 2003). Given the currency board and limited wage–price flexibility, the larger the necessary real exchange-rate adjustment, the more severe the contraction in domestic economic activity required to generate the required trade surplus and the smaller the likelihood of success, given the negative effect of economic contraction on government revenues. Second, because much of public sector borrowing was in dollars, the actual ratio of debt to GDP is highly sensitive to changes in the equilibrium real exchange rate. Thus, the official debt figures would severely understate the ratio of public debt to GDP in the event of a large depreciation of the equilibrium real exchange rate. Indeed, Perry and Servén (2003) show that the ratio of public debt to GDP would have been much higher in Argentina after 1998 if evaluated at the equilibrium real exchange rate.

The upshot of the first point is that a closed economy with a fairly rigid real exchange rate can only sustain relatively small amounts of external debt, while that of the second point is that Argentina's true debt was actually much larger than the already large numbers indicated by official figures.

5.4.2.2 | Currency Mismatches

The second component of Argentine vulnerability was the existence of large currency mismatches in the balance sheets of the government as well as of the corporate sector. Though the government's revenues were accumulated in pesos, its debt was largely denominated in dollars, as indicated above. The banking system also had large liabilities in foreign exchange, particularly in the form of time and savings deposits. Although banks denominated many of their loans in dollars as well, thereby avoiding direct currency mismatches in their own balance sheets, many of those loans were to firms producing nontraded goods. Indeed, the average share of debt denominated in dollars in the nontraded goods sector was estimated at about 80 percent in 1998–1999 by De la Torre et al., (2003). Thus, the corporate sector had significant balance sheet currency mismatches, which exposed it to exchange-rate risk. This exchange-rate risk in turn became credit risk for the banking system, because its customers would be unable to repay their loans in the event of a real exchange-rate depreciation.

The implication is that a real depreciation would have adverse effects for the balance sheets of the government, the banking system, and the corporate sector.

5.4.3 | A "Perfect Storm" in 1998–2001

Unfortunately for Argentina, these vulnerabilities were exposed by a series of adverse shocks in the second half of the 1990s, which together called for a substantial real exchange-rate depreciation after 1998. These shocks consisted of the following:

- Beginning in the mid-1990s the U.S. dollar, which was the anchor currency for the currency board, itself experienced a significant appreciation. Because Argentina sends only 12 percent of its total exports to the United States, the dollar surge was associated with an appreciation of the effective real exchange rate of the Argentine peso.
- The Asian financial crisis in 1997–1998 resulted in a substantial drop in Argentina's export commodity prices after 1997. This adverse movement in the terms of trade would tend to be associated with a depreciation in the country's *equilibrium* real exchange rate.
- As documented by Calvo et al. (2003), the Russian crisis in August 1998 resulted in a drying up of capital flows to emerging market economies—including Argentina—and a large increase in sovereign spreads, again a factor that would call for a depreciation in Argentina's equilibrium real exchange rate.

- A recession emerged in Brazil, Argentina's largest trading partner, in 1998.
- As described above, the Brazilian recession culminated in a currency crisis in Brazil in early 1999, which resulted in a sharp depreciation of the Brazilian *real*, magnifying the appreciation of Argentina's actual real effective exchange rate.
- The collapse of the NASDAQ in the spring of 2000 presaged the beginning of a world recession in that year, with adverse effects on the demand for Argentine exports and therefore for economic activity in Argentina.
- Finally, the crisis in February 2001 in Turkey, a country that, like Argentina and Brazil, had pursued an exchange-rate-based stabilization policy, created doubts about the sustainability of the Argentine currency board.[37]

The upshot from all of these shocks was that a recession began in Argentina during the second half of 1998, and continued through the collapse of the currency board at the end of 2001.

Though the recession was triggered by the combination of the adverse external shocks just listed, it was sustained by the inability of the Argentine government to counter those shocks by using stabilization policy. On the one hand, neither devaluation nor expansionary monetary policy were feasible options as long as the currency board was maintained, and adopting an expansionary fiscal policy in the context of the currency board was ruled out by the size of the public debt and the questions it raised about Argentina's fiscal solvency. On the other hand, abandoning the currency board to pursue an expansionary monetary policy with a more depreciated exchange rate was not an attractive alternative in the face of the currency mismatches in the balance sheets of the government and of firms in the nontraded goods sector, as well as the implications of these mismatches for the health of the banking system in the event of a devaluation. In short, to avoid a recession Argentina needed simultaneously to depreciate the real exchange rate as well as to allocate the losses that such a depreciation would imply in the face of widespread currency mismatches. The political system was unable to rise to this challenge. As a result, the recession that began in mid-1998 proved to be long-lasting. By 2001, the economy was in its fourth year of recession, and the unemployment rate stood at about 16 percent.

5.4.4 | The Crisis

Unfortunately, this situation could not be sustained for long, because the government's prospective insolvency and the recession tended to aggravate each other through an unfavorable debt dynamic. Perry and Servén (2003)

[37] See Yilmaz and Boratav (2003) for a discussion of Turkey's lira crisis.

estimate that by 2001 the Argentine peso was overvalued by some 40 percent, and that the adjustment in the government's primary surplus that would have been required to stabilize the debt/GDP ratio at the equilibrium real exchange rate exceeded 5 percent of GDP in 2000 and 9 percent of GDP by 2001. Not surprisingly, markets were skeptical that such an adjustment would prove to be economically and politically feasible. Therefore, by late 2000, the spread on Argentine government bonds over the U.S. Treasury Bill rate had risen to 750 percent. These fears over debt sustainability were magnified by the adverse effects of the economic contraction on the government's tax revenues, and therefore on its ability to service debt. Heightened fears over the government's solvency caused nominal interest rates to rise, which aggravated the fiscal deficit by both increasing the government's interest expenditures and reducing its tax revenues as the result of the adverse effects of higher interest rates on economic activity. In short, the fears over debt sustainability became self-sustaining, because the increase in real interest rates that they engendered itself made it more difficult to service the debt.

This cycle at the same time represented a threat to the convertibility plan, because given that a real depreciation was inevitable, the best hope for the balance sheets of the government, the firms, and the banks was to bring the real depreciation about without aggravating the recession. The currency board did not seem to offer this option. The upshot is that a combination of nominal devaluation, together with the implementation of some mechanism for allocating the losses arising from currency mismatches, seemed to be in the offing.

The crisis was prompted by a bank run that materialized between July and November 2001. A total of $15 billion was withdrawn from banks during that time. De la Torre et al. (2003) argue that the perception of currency risk mentioned above triggered the run, citing as evidence the fact that the initial shift was from peso to dollar deposits between February and July–August. Only later was this followed by a generalized run on bank deposits of both types. Large withdrawals from banks and losses of foreign exchange reserves continued throughout the month of November. By the end of the month, the central bank's foreign exchange reserves were down to $15 billion, barely enough to cover currency in circulation, and the game was up.

Controls on bank withdrawals were implemented on December 1 (the *corralito*), limiting Argentines to withdrawing $1,000 per month from bank accounts. On December 5, the IMF said it could not recommend completion of the scheduled review of its adjustment program with Argentina, which meant a $1.5 billion tranche that was due at the end of the year would not be released. The *corralito* led to riots that prompted a political crisis. As a result, Finance Minister Cavallo resigned on December 18, followed by President De la Rua on December 20. Interim president Rodriguez Saa, a former provincial governor, declared a moratorium on the $155 billion of public foreign-currency debt on December 23, by which time the price of government bonds had fallen to

one-fourth of their face value. This represented the largest default on sovereign debt in history. Rodriguez Saa himself resigned on December 30. Eduardo Duhalde, the Peronist candidate who had opposed De la Rua in the elections of 1999, became president on January 2, and ended the currency board by announcing a floating of the peso. The Argentine economy, which had contracted by 4.4 percent in 2001, endured a contraction of nearly 11 percent in 2002.

APPENDIX: Credibility, Reputation, and Currency Crises

This Appendix discusses an extension of the Drazen–Masson approach by Agénor and Masson (1999), which addresses the behavior of exchange-rate expectations in the periods preceding the December 1994 Mexican peso crisis.[38]

Formally, let the policymaker's one-period loss function L be given by

$$L = (i - \tilde{\imath})^2 + \theta \Delta e, \quad \theta > 0 \tag{A.1}$$

where i is the interest rate on domestic-currency-denominated assets (with $\tilde{\imath}$ its desired level), e the (logarithm of) the nominal exchange rate (measured as units of domestic currency per unit of foreign currency) and the weight θ can take on one of two values θ^w and θ^T, for weak and tough governments respectively, with $\theta^T > \theta^w$.

Let R be official reserves, the change in which depends on the differential between the domestic interest rate i and the foreign interest rate i^* plus expected devaluation ε^a, on relative prices, and a random shock, u:

$$\Delta R = \alpha(i - i^* - \varepsilon^a) + \gamma(e + p^*_{-1} - p_{-1}) - u_1, \tag{A.2}$$

where $\alpha, \gamma > 0$. p (p^*) denotes the logarithm of domestic (foreign) prices.

The domestic interest rate is determined by the equilibrium condition of the domestic money market, which is given by

$$i = \delta_0 - h, \tag{A.3}$$

where h denotes the (logarithm of the) base money stock defined in proportion of nominal output at the previous period, which, assuming partial sterilization, can be related to its lagged value and changes in official reserves:

$$h = \mu_1 h_{-1} + \mu \Delta R + u_2, \quad 0 < \mu_1 < 1, \quad \mu > 0, \tag{A.4}$$

where u_2 is a random term.[39]

[38] The notion of credibility used by Agénor and Masson (1999) is by no means the only possible one. As indicated in Chapter 13, Cukierman and Liviatan (1991), for instance, use an alternative concept according to which credibility is defined as the ability of the government to precommit its actions—that is, its capacity to convince private agents that it will carry out policies that may be time-inconsistent.

[39] With full sterilization, $\mu = 0$. The implications of full sterilization for the functioning of the model are discussed below.

Normalizing constant terms to zero, Equations (A.2), (A.3), and (A.4) yield

$$i = \Omega^{-1}\left\{-\mu_1 h_{-1} + \alpha\mu(i^* + \varepsilon^a) - \gamma\mu(e + p^*_{-1} - p_{-1}) + u\right\}, \tag{A.5}$$

where $\Omega = 1 + \alpha\mu$, and $u \equiv \mu u_1 - \delta u_2$.

Let L^F be the value of the loss function if the exchange rate is kept fixed, and L^D the value when the exchange rate is devalued. The government therefore devalues when $L^D - L^F < 0$.

To determine L^D and L^F, note first that from Equation (A.5) if the authorities do not devalue (so that $\Delta e = 0$), domestic interest rates are at the level:

$$i^F = \Omega^{-1}\{-\mu_1 h_{-1} + \alpha\mu(i^* + \varepsilon^a) - \gamma\mu z_{-1} + u\},$$

where competitiveness z is defined as $e + p^* - p$.

If, on the contrary, the authorities opt to devalue, $e = e_{-1} + d$, where the devaluation size d is assumed exogenous. In that case, using the previous result, we have

$$i^D - \tilde{\imath} = (i^F - \tilde{\imath}) - \Omega^{-1}\gamma\mu d,$$

which shows that domestic interest rates are lower relative to their desired value when the authorities devalue (because the level of reserves, and thus the money stock, are higher), compared to a situation where they do not devalue. The second step is to substitute out the previous expression in Equation (A.1), so that

$$L^D - L^F = \frac{\mu\gamma d}{\Omega}\left\{\frac{\mu\gamma d}{\Omega} - 2(i^F - \tilde{\imath})\right\} + \theta d. \tag{A.6}$$

From the above expressions, it can be shown that $L^D - L^F < 0$ only when

$$\varepsilon > \tilde{\varepsilon} \equiv \mu_1 h_{-1} + \kappa - \alpha\mu(i^* + \varepsilon^a) + \gamma\mu z_{-1}, \tag{A.7}$$

where $\kappa = \Omega\tilde{\imath} + \mu\gamma d/2 + \theta\Omega^2/2\gamma\mu$. Because θ can take on one of two values θ^w or θ^T (indicating a weak or tough government, respectively), $\tilde{\varepsilon}$ (through κ) depends on the policymaker's type.

The expected devaluation rate is the product of the devaluation probability ρ and the devaluation size d. The private sector's assessment of the probability of devaluation ρ is equal to the probability of a weak government times the probability that a weak government will devalue ρ^w, plus a corresponding term for a tough government:

$$\rho = \pi\rho^w + (1 - \pi)\rho^T. \tag{A.8}$$

The expected devaluation rate is thus

$$\rho d \equiv \varepsilon^a = [\pi\rho^w + (1 - \pi)\rho^T]d. \tag{A.9}$$

From Equation (A.7), ρ^h can be defined as follows, for $h = w, T$:

$$\rho^h = \Pr(u > \tilde{u}^h).$$

If u is assumed to follow a uniform distribution in the interval $(-v, v)$, with $2v > \alpha\mu d$, then

$$\rho^h = (v - \tilde{u}^h)/2v. \tag{A.10}$$

Using Equations (A.7) to (A.10), we can solve for ρd:

$$\varepsilon^a = \frac{d}{1-\alpha\mu d/2v}\left\{\frac{\pi(\kappa^T-\kappa^w)}{2v} + \frac{1}{2v}\left[v-\kappa^T-\mu_1 h+\alpha\mu i^*-\gamma\mu z_{-1}\right]\right\}, \tag{A.11}$$

where $\kappa^T > \kappa^w$.

The equation for the expected devaluation rate that can be estimated is thus given by

$$\varepsilon^a = a_0 + a_1\pi + a_2 i^* + a_3 z_{-1} + a_4 h_{-1} + \zeta, \tag{A.12}$$

where $a_1 > 0$, $a_2 > 0$, $a_3 < 0$, $a_4 < 0$, and ζ is an error term. Thus, given the assessment of a government's type π, a larger level for the beginning-of-period money stock or a depreciation of the real exchange rate lowers the expected devaluation rate, while a higher value for the foreign interest rate raises it.

The updating equation for the probability of a weak government π is derived from Bayesian updating:

$$\pi = \frac{1-\rho^w_{-1}}{(1-\rho^w_{-1})\pi_{-1} + (1-\rho^T_{-1})(1-\pi_{-1})}\pi_{-1}. \tag{A.13}$$

Substitution of (A.10) for ρ^w and ρ^T in Equation (A.13) and linearizing gives

$$\pi = b_1\pi_{-1} + b_2 i^*_{-1} + b_3 z_{-2} + b_4 h_{-2} + \zeta', \tag{A.14}$$

where $0 < b_1 < 1$, $b_2 < 0$, $b_3 > 0$, $b_4 > 0$, and ζ' is an error term. The updating equation for π has the opposite sign [compared to Equation (A.12)] for the lagged values of the foreign interest rate, the real exchange rate, and the money stock, conditional on no devaluation having occurred. For instance, the willingness to accept a loss of competitiveness without devaluing is viewed as evidence that policymakers are less likely to be weak—and hence leads to a lower value of π.

16

Banking Crises and Twin Crises

The spate of financial crises that developing countries have undergone over the past two decades has included not just sovereign debt and currency crises, as examined in previous chapters, but a large number of domestic banking crises as well. Banking crises are systemic or near-systemic breakdowns of the domestic financial sector in which a large number of banks find themselves with significant reductions in their net worth, forcing them to go out of business or otherwise severely curtail their activities. Such events severely disrupt domestic financial intermediation, generally involve large fiscal costs, and often have harmful effects on real economic activity. According to Caprio and Klingebiel (2003), there were 112 systemic banking crises in 88 developing countries from 1975 to 2001. Many of the most dramatic financial collapses in middle-income developing countries during recent years, including the 1994 Mexican crisis, the 1997–1998 Asian crisis, and the 2001 Argentine crisis (as documented in the previous chapter), included a breakdown of the domestic financial system as an important component. In a formal study of both aggregate and bank-level data for as many as thirty five countries, Demirgüç-Kunt et al. (2006) found that banking crises are followed by a sharp (albeit short-lived) drop in the growth rate of output and a credit crunch. Tornell and Westermann (2002, 2003) also found that the aftermath of crises is often characterized by a (short-lived) recession and a protracted credit crunch, which affects mostly (small) firms in the nontradables sector and persists long after the resumption of growth. Kroszner et al. (2007), using data for thirtyeight developed and developing countries, found that industries that are highly dependent on external finance tend to experience a substantial contraction of value added during a banking crisis; this adverse effect is magnified in countries with deeper financial systems. One reason for such large effects is the link between credit and the supply side through working-capital needs, as discussed in Chapters 6 and 7.

As those examples suggest, sovereign debt, currency, and banking crises are not independent of each other. A variety of channels exist through which the occurrence of each type of crisis may make one of the others more likely. Indeed, the real domestic costs of currency crises in developing countries may largely depend on the extent to which they trigger a sovereign debt or a domestic banking crisis. Having examined in Chapter 4 the fiscal sustainability issues involved in the emergence of soverign debt crises and in Chapter 15 the factors associated with the emergence of currency crises, in this chapter we focus on domestic banking crises, as well as on some of the channels through which banking crises may cause both sovereign and currency crises.

The increased incidence of banking crises in developing countries in recent years has coincided in timing with domestic financial liberalization in developing countries, which became widespread during the decade of the 1980s (see Chapter 18). Financial liberalization means the removal of the restrictions associated with financial repression, including the freeing of bank interest rates to be determined by market forces, lowering or abolishing reserve and liquidity requirements on banks, removing directed credit regulations, adopting indirect instruments of monetary control (instead of imposing credit ceilings on individual banks), opening up entry into the financial sector (including privatization), and opening up the capital account of the balance of payments. These measures were undertaken to accelerate financial development, prompted in part by the accumulation of evidence that financial development can have important positive effects on economic welfare and growth in developing countries.[1]

However, an important lesson conveyed by the spate of banking crises that have occurred during the post-financial liberalization period in developing countries is that it matters—and matters a lot—how financial reform is carried out. A laissez-faire approach to financial reform would have the government undertake the desired reform measures and then rely on competition and market efficiency to ensure the appropriate functioning of the newly deregulated financial system. There are two fundamental problems with this approach. The first is that in the presence of asymmetric information and opportunistic behavior, there is no necessary presumption that unregulated competitive banking markets will be Pareto efficient, so a laissez-faire approach may result in a systematic misallocation of resources by the liberalized financial system, undermining the growth benefits expected to ensue from financial liberalization. The second is that, even in the absence of the problems of asymmetric information and opportunistic behavior that may tend to undermine microeconomic welfare gains, in contrast with a severely repressed financial system a fully liberalized one may be vulnerable to highly disruptive periodic banking crises. As Carlos Díaz-Alejandro put it in the title of a famous paper on this topic, the post-liberalization situation may be characterized as "good-bye financial repression, hello financial crash" (Diaz-Alejandro, 1985).

In this chapter we will explore how such financial crashes can come about. The next section examines how banking crises can emerge even when problems of asymmetric information and opportunistic behavior are absent—that is, even when a liberalized domestic financial system plays a welfare-enhancing role in the domestic economy. Section 2 examines models that adopt the framework of Section 1 to explore how banking crises may be linked to currency crises, the so-called "twin crisis" phenomenon. In Section 3 we examine the implications of asymmetric information and opportunistic behavior for both the efficiency of resource allocation by the financial sector and the likelihood of financial

[1] For further discussion, see Chapter 17.

crashes. Section 4 concludes the chapter by describing some recent empirical work on the determinants of banking system distress in developing countries.

1 | Banks as Maturity Transformers

Explanations of banking crises must take as their point of departure an interpretation of the economic role of banks. One such interpretation views banks primarily as maturity transformers. From this perspective, banks play the valuable social role of allowing individuals who place a high premium on liquidity to nevertheless use their savings to finance illiquid social investments that yield high returns. Banks can achieve this result by offering their individual depositors highly liquid assets and using these resources to fund investments that, while yielding high returns, require a long period to mature. They are able to do this essentially by pooling the idiosyncratic liquidity shocks that their depositors face into an aggregate liability portfolio from which liquidity shocks are effectively eliminated. But precisely because their individual depositors require instant access to their funds while banks' assets take a long time to mature, vulnerability to panic is inherent in the very activity of banking. The key problem is that even solvent banks will not typically have the liquid resources on hand to meet unusual demands for withdrawals by their depositors. Because its long-maturity assets lose value if they are liquidated prematurely, a bank that tries to meet such unusual demands by liquidating assets may find itself becoming insolvent. This means that in the event of unusual demand, some depositors will lose at least some of the value of their claims on the bank. An important feature of the liquid liabilities of banks—that their depositors have access to them on a first come-first served basis (the sequential servicing constraint)—means that depositors who anticipate this loss of value will have an incentive to "run," that is, to withdraw their assets first, even in the absence of a liquidity motive to withdraw funds. The implication is that, precisely because of its illiquid portfolio structure, a run on a bank can be a rational expectations equilibrium.

1.1 | The Diamond–Dybvig Framework

The canonical model of such bank liquidity crises was developed by Diamond and Dybvig (1983). The model simultaneously illustrates the welfare gains provided by banks and their vulnerability to panic. Because this model has provided the basis for much subsequent analysis of banking crises, we describe it in some detail in this section.[2]

[2] Kawamura (2007) presents a small-open-economy, two-good version of the Diamond–Dybvig model with cash constraints and analyzes the implications for banking of different exchange-rate regimes and monetary policies.

Consider a three-period world populated by a continuum of initially identical consumers, each of whom receives an endowment of one perfectly divisible good in period 0 and makes consumption decisions in periods 1 and 2 (there is no consumption in period 0). In period 0, any fraction of the good can be costlessly stored or invested in an illiquid production technology, that is, a technology with the property that if production is aborted in period 1 the technology yields one unit of output for each unit of the good invested, while if production is allowed to continue until period 2, it yields $R > 1$ goods for each good invested. Consumers are allowed to enter into contracts to trade current for future consumption in both periods 0 and 1. However, the assumed linear technology fixes the relative price of period 2 consumption in terms of period 1 consumption at R^{-1}, and that of period 1 consumption in terms of period 0 goods at unity.

A motivation for intertemporal trade arises because in this model consumers are only identical in period 0. At the beginning of period 1 each individual consumer may or may not be subjected to an idiosyncratic "liquidity shock." This shock causes a fraction λ of all consumers to turn out to be "type A"consumers who care only about consumption in period 1, while a fraction $(1-\lambda)$ turn out to be "type B" consumers who care only about consumption in period 2. The utility of consumption for type A consumers in period 1 is given by $u(c_1)$, where c_1 is the period 1 consumption of a type A consumer. The utility function has the properties $u'(\cdot) > 0$, $u''(\cdot) < 0$, and satisfies the Inada conditions. The period 1 value of the utility of type B consumers is given by $\rho u(c_2)$, where c_2 is the period 2 consumption of a type B consumer and $1 > \rho > R^{-1}$, so $\rho R > 1$. The coefficient of relative risk aversion, given by $-cu''/u'$, is assumed to always be greater than unity.

Because consumers are risk averse, they would be willing to pay in period 0 to reduce the uncertainty that they face in this environment. Thus, it would be optimal for them to design insurance contracts in period 0 that distribute their consumption optimally across the two possible states of nature in which they might find themselves in periods 1 and 2 (that is, type A and type B). The resulting optimal equilibrium allocation of consumption for the two types of agent in the two periods would satisfy the conditions:

$$u'(c_1) = \rho R u'(c_2), \tag{1}$$

$$(1-\lambda)c_2 = R(1-\lambda c_1). \tag{2}$$

The first condition sets the ratio of marginal utilities across the two states of nature equal to the relative price of consumption in the two states, while the second condition reflects the economy's aggregate resource constraint. Achieving this allocation, however, requires that consumers be able to make payments to and receive payments from other consumers in period 1 that are contingent on the consumer's revealed type in that period. To see what form such payments would take, note from the properties of the utility function

that in the optimal allocation just described, $c_2 < R$, while $c_1 > 1$. Because their endowments would allow type A consumers to consume one unit of the good in period 1 and type B consumers to consume R units in period 2, the optimal insurance contracts therefore involve period 1 payments from type B to type A consumers. However, a key assumption of the Diamond–Dybvig model is that the consumers' revealed types are private—not public—information. The implication of this assumption is that contracts cannot be written that are contingent on the consumer's type, because that type is unverifiable to the other party in the contract. This means that consumers cannot write insurance contracts that allocate utility optimally across states of nature.

Diamond and Dybvig explore what this constraint implies for the competitive equilibrium of this economy. They argue that because consumers are unable to write state-contingent contracts, no trading would actually take place in a competitive equilibrium. No trading takes place in period 0, because consumers are identical ex ante then, and they cannot write contracts contingent on their revealed differences in period 1. Similarly, no trading takes place after "types" have been revealed in period 1, because while consumers have different preferences about when to consume once they find out what "type" they are, they all have access to the same technology for converting period 1 into period 2 resources, so there is no opportunity for mutually advantageous trades. The upshot is that the competitive equilibrium is autarchic: type A consumers simply abort production and consume their endowments in period 1, attaining utility $u(1)$, with marginal utility $u'(1)$, while type B consumers do not abort production, reaping the higher-return benefit of allowing production to continue until period 2 and achieving utility $\rho u(R)$, with marginal utility $\rho u'(R)$. Diamond and Dybvig show that $\rho R u'(R) < u'(1)$, so the competitive equilbrium does not satisfy the optimality conditions described above.

Banks can provide a solution to this problem that allows the optimal allocation of consumption to be achieved. They can do so by offering deposits in period 0 that are available on demand in period 1 and yield a return that exceeds that of the pure storage technology, making such deposits attractive to all consumers. Such deposits pay a return r_1 if they are withdrawn by the jth agent during period 1, *as long as the bank has the resources to make the payment*, that is, as long as f^j is less than r_1^{-1}, where f^j is the fraction of all deposits withdrawn before the jth individual presents her deposit for withdrawal, and pays 0 if $f^j \geq r_1^{-1}$, because the bank's resources would be exhausted before the jth individual tries to withdraw in this case. In period 2, the bank pays out the resources that it has left to its remaining depositors, paying $R(1-r_1 f)/(1-f)$ per unit of deposit made in period 0, where f is the fraction of all deposits withdrawn in period 1, unless its resources were exhausted in period 1, in which case it pays 0.

The bank can mimic the complete information equilibrium if it sets $r_1 = c_1$. To see how, note that if type A consumers all withdraw their deposits

in period 1, they consume c_1 in period 1, exactly as in the perfect-information equilibrium. The deposits not withdrawn remain invested in the illiquid technology. The bank's payout to the type B consumers in period 2 is given by its resource constraint. It distributes:

$$R(1-r_1 f)/(1-f) = R(1-c_1\lambda)/(1-\lambda) = c_2, \tag{3}$$

per unit of deposit in period 2 to the fraction $(1-\lambda)$ of their depositors who happen to be type B consumers and leave their deposits in the bank until the second period. The equilibrium just described is a rational expectations equilibrium, because type A consumers who withdraw their deposits in period 1 do not regret doing so, while type B consumers who do *not* withdraw in period 1 also do not regret having left their assets in the bank.

Unfortunately, this is not the only possible rational expectations equilibrium. The problem is that there is no guarantee that $f = \lambda$ in period 1. In other words, the fraction of deposits withdrawn in that period may not be limited to those withdrawn by type A consumers. Suppose, in particular, that $f = r_1^{-1}$, so *all* of the bank's deposits are exhausted by first-period withdrawals. For this to happen, some type B consumers must also withdraw their deposits in period 1, taking advantage of the free storage assumption to consume c_1 (the contractual return paid by the bank in period 1) during period 2. It is rational for them to do so, because the sequential service constraint implies that those type B consumers who attempt to withdraw their funds after the bank's resources have been exhausted receive no return at all in period 2, and thus are worse off than if they had been among the lucky few who got their deposits out in time. Thus, an equilibrium in which type B consumers stage a "run" on the bank is also a perfect foresight equilibrium.

In short, banks that provide liquidity services are inherently vulnerable to runs. Because $c_1 < c_2$, it is easy to show that type A consumers can be no better off in the event of a bank run equilibrium, while type B consumers must be worse off, so the bank run equilibrium is strictly inferior to the no-run equilibrium. The intuition for this is that the run forces the premature liquidation of assets, so that de facto the economy as a whole invests in the storage technology, rather than in the production technology. Diamond and Dybvig identify two possible solutions to this problem: the suspension of payments by the bank, and deposit insurance. We will come back to these later.

1.2 | Business Cycles and Banking Crises

The Diamond–Dybvig model does not specify the conditions under which a bank panic is likely to take place. Because both the "run" and "no run" outcomes are rational expectations equilibria, either outcome is possible at any time. However, subsequent research has shown that banking crises are empirically systematically related to a variety of macroeconomic developments.

An early finding by Gorton (1988), for example, was that during the National Banking era in the United States (1863–1914) a systematic relationship existed between business cycles and banking crises: banking crises were much more likely to happen during recessions. This finding can be given a straightforward interpretation in the context of the Diamond–Dybvig model; if business cycle recessions are periods when liquidity shocks are more likely to happen (so that λ increases), or when expectations of future returns on illiquid investments (R) fall, then panics are more likely to happen during recessions. Gorton also found, as suggested by the Diamond–Dybvig analysis, that the creation of a lender of last resort for banks in the United States (in the form of the Federal Reserve System in 1914) and of deposit insurance (in the form of the Federal Deposit Insurance Corporation in 1934) were associated with a reduction in the incidence of bank panics.

Theoretical underpinnings for these findings are provided by Gorton and Huang (2006), who develop a model in which banking panics are not irrational manifestations of multiple equilibria. Rather, these episodes are the outcomes of asymmetric information and depositors monitoring their banks, which are vulnerable to moral hazard problems in certain states of the world. Specifcally, depositors lack full information about the value of bank assets, so that during macroeconomic downturns they monitor their banks by withdrawing in a banking panic. Such panics may involve inefficiencies because banks may be liquidated for no good reason: because there is not enough liquidity in the banking system, banks cannot honor the demands of all depositors. Efficiency can be improved by having a central bank that creates liquidity if needed. This also mitigates moral hazard problems.

We will provide a brief review of the evidence on the systematic determinants of banking crises in developing countries in Section 4. Before doing so, however, we turn to a consideration of the relationship between banking and currency crises.

2 | Twin Crises

The dramatic concurrence of banking and currency crises in the Southern Cone countries of Latin America during the early 1980s alerted economists to the possibility that these phenomena may exhibit particularly close links in the context of developing countries. An early recognition of these links was in the already-cited paper by Díaz-Alejandro (1985), who first drew attention to the close connection between the two types of crises in the Southern Cone.

Subsequently, Kaminsky and Reinhart (1999) undertook a more systematic relationship of the empirical association between the two types of crises, for which they coined the term "twin crisis." To investigate the relationship between banking and currency crises, they examined a sample of seventy six currency and twenty six banking crises in twenty five countries (twenty of

which were developing countries) from 1970 to 1995[3]. They found that there was actually little relationship during the 1970s, before financial liberalization gathered momentum among developing countries, but that the two types of crises became closely linked in the post-liberalization period. Specifically, though troubles in the banking system tended to predate currency crises (and indeed the occurrence of banking crises helped to predict subsequent currency crises), the outbreak of a currency crisis had the effect of deepening the banking crisis. Both types of crises tended to be preceded by a deterioration in macroeconomic fundamentals and specifically, consistent with Gorton's historical evidence for the United States, by a recession brought on by a worsening of the terms of trade, an overvalued real exchange rate, or rising cost of credit. Importantly, Kaminsky and Reinhart found that currency and banking crises had much more severe effects on the economy when they occurred jointly than when they appeared in isolation.

In the rest of this section we examine two generations of analytical models that attempt to explain the link between banking and currency crisis. The first, by Velasco (1987), adopts a first-generation currency crisis framework and explains the occurrence of a currency crisis as the result of a government bailout of a troubled banking system. The second, by Chang and Velasco (2001), adopts a third-generation currency crisis perspective (as discussed in the previous chapter) and models the joint occurrence of a banking crisis and a sudden stop of capital inflows as outcomes of simultaneous panic on the part of domestic depositors and the domestic banking system's foreign creditors.

2.1 | A Basic Model with Close Linkages

An early model of the relationship between banking and currency crises was developed by Velasco (1987). This model essentially shows how government guarantees of the liabilities of private banks can generate a standard first-generation currency crisis very similar to that analyzed by Krugman (1979) and discussed in Chapter 15. The mechanism is as follows: in the presence of government guarantees for the liabilities of the domestic banking system, a failure of that system causes a deterioration in the government's budget, which is financed through a depletion of foreign exchange reserves. Given a lower bound on such reserves, their steady depletion must result in a first-generation currency crisis.

Velasco begins by describing a simple dynamic economy without banks. In the style of early first-generation balance-of-payments crisis models, he assumes that the domestic economy is small and produces a single traded good, so the domestic price level is determined by PPP as $p_t = s$, where s is the nominal exchange rate (price of foreign currency in terms of domestic

[3] Evidence that twin crises tend to occur more frequently in developing countries is also provide a by Glick and Hutchison (1999).

currency) and the foreign-currency price of the traded good is normalized to unity. Domestic prices and wages are fully flexible, so domestic output is always at its full employment level y. Uncovered interest parity ensures that the domestic nominal interest rate i is always equal to the foreign rate i^*. The domestic demand for money is given by:

$$m_t = L(i^*)w_t, \tag{4}$$

where w_t is private nonbank wealth. The money supply is fully backed by foreign exchange reserves, which pay interest to the government at the rate i^*. The government is assumed to simply consume the interest earnings on its foreign exchange reserves, so government consumption g is:

$$g_t = i^* R_t. \tag{5}$$

As we will see below, the government's stock of foreign exchange reserves will be constant initially, so government consumption is constant as well. The wealth of the private nonbank sector is defined as:

$$w_t = m_t + b_t^* + y/i^*, \tag{6}$$

where b_t^* denotes domestic private holdings of foreign bonds. Private sector wealth accumulation is accordingly given by:

$$\dot{w}_t = y + i^* b^* - c(w_t) = i^*(w_t - m_t) - c(w_t), \tag{7}$$

where c is real private consumption, taken to be an increasing function of real private wealth, and the second equality follows from substituting Equation (6) into the first part of Equation (7). Substituting (4) into (7), the steady-state level of wealth in the economy is defined implicitly by:

$$0 = i^*[w_t - L(i^*)w_t] - c(w_t). \tag{8}$$

Velasco introduces banks by assuming that the economy's capital stock is held indirectly by the nonbank sector, with banks serving as the financial intermediary, as in Diamond and Dybvig. In effect, the capital stock is transfered by the nonbank private sector to a bank, which in return issues claims on the bank to the nonbank private sector. In this case, however, those claims are in the form of domestic bonds, rather than demand deposits. The present value of the private bonds issued must equal that of the economy's future output, or $b_0 = y/i^*$, so in the presence of banks the private nonbank sector's wealth becomes $w_t = m_t + b_t^* + b_0$. The production of the single traded good is assumed to be subject to economies of scale, allowing the bank to earn monopoly profits equal to π per period, so in the presence of such economies the economy's output becomes $y' = y + \pi$. The banker is assumed to consume all of these excess profits.

The next step is to consider the effects of an exogenous shock to this economy, in the form of a contraction in y. Because the bank is committed to paying out $i^* b_0$ per period, the private nonbank sector does not perceive a

change in its wealth, and therefore does not alter its consumption behavior. If the shock is small enough, the bank can continue to meet its obligations to its private creditors by simply reducing its own income π. But if the shock is sufficiently large that it exceeds what the bank can pay out of its own income, the bank can only continue to meet its obligations by borrowing. Assuming for simplicity that the shock is so large that it drives y' to zero, bank borrowing per period, denoted $\dot{F}_t$, is given by:

$$\dot{F}_t = i^* b_0 + \pi + i^* F_t. \tag{9}$$

Because neither the private sector nor the banker initially changes its consumption behavior, what happens in this situation is that the larger current-account deficit caused by the reduction in y' is financed by external borrowing on the part of the bank. However, if this external borrowing has an upper bound, say F_u, then this situation must eventually come to an end. The critical moment T when the bank's borrowing capacity is exhausted, that is, when $F_T = F_u$, is given by:

$$e^{i^* T} = \frac{i^* F_u + i^* b_0 + \pi}{i^* b_0 + \pi}. \tag{10}$$

Velasco assumes that bank deposits and the bank's foreign debt are guaranteed by the government. However, the government is assumed not to have sufficient foreign exchange reserves to simultaneously redeem the private bank's deposits and pay off its external debt. He therefore assumes that the government uses reserves to redeem the bank's deposits, but simply takes on the bank's external debts and continues to service them on schedule. If the government consumed the amount g initially, then its reserves must have been given by g/i^*, and the initial evolution of its reserves over time would have been given by:

$$\dot{R}_t = 0 = g - i^* R_0. \tag{11}$$

When it pays off the bank's depositors, its reserves fall by b_0, so its revenues fall by $i^* b_0$. In addition, when it assumes the bank's debts, its spending rises by $i^* F_u$. Thus, the dynamics of reserves become:

$$\dot{R}_{t-T} = i^* R_{t-T} - (i^* F_u + g). \tag{12}$$

The key point of the model is that because $R_T = R_0 - b_0 = g/i^* - b_0$, the bailout of the private bank makes $\dot{R}_{t-T} < 0$ for all $t \geq T$. Thus, as in the canonical Krugman (1979) model, there is an inexorable decrease in the stock of reserves which, assuming a finite lower bound on reserves, must inevitably give rise to a successful speculative attack on the currency. As in the Krugman model, the timing of the attack is predictable, and assuming a zero lower bound on reserves, is given implicitly by:

$$e^{i^*(T^*-T)} = \frac{R_{T^*-T} - (F_u - g/i^*)}{(R_0 - b_0) - (F_u - g/i^*)}. \tag{13}$$

Note that the link between a banking crisis and an eventual currency crisis in this model operates through the government's budget. Consistent with the results of Gorton and Kaminsky-Reinhart, what triggers the banking crisis is a recession, which impairs the value of the bank's assets. Because it guarantees the value of the banking system's liabilities, this shock to the system's net worth is absorbed by the government, which is thereby caused to run a fiscal deficit that eventually forces it to run out of reserves, triggering the currency crisis.

2.2 | The Chang–Velasco Framework

In the Velasco (1987) model, causation therefore runs directly from the banking crisis to a currency crisis. In the more recent model by Chang and Velasco (2001), by contrast, domestic and external financial crises occur simultaneously as the result of a joint panic by domestic and external creditors of the domestic banking system. Chang and Velasco build directly on the Diamond–Dybvig model. As in the latter, they adopt a three-period setup in which agents are born in period zero and receive e units of a perfectly divisible endowment good. In period 0, the good can be invested either at home or abroad. Domestic investments are subject to an illiquid technology, which yields a return $r < 1$ per unit invested if the investment is liquidated in the first period, and $R > 1$ if it is held until the second period. The foreign investment, which replaces the storage technology in Diamond and Dybvig, yields one unit of consumption in either period 1 or period 2, depending on when it is liquidated. Domestic agents can also borrow abroad at zero interest in periods 0 and 1, with a ceiling on their total external borrowing equal to f units of the consumption good. As in Diamond and Dybvig, consumers discover in period 1 whether they are type A (who care only about consumption in period 1) or type B (who care only about consumption in period 2), and this is assumed to be private information. The probability of being a type A consumer is λ, while that of type B is $(1-\lambda)$. As of period 0, expected utility is thus given by:

$$\lambda u(c_1) + (1-\lambda) u(c_2), \tag{14}$$

where $u(\cdot)$ now explicitly takes the constant relative risk aversion form $u(c) = c^{1-\sigma}/(1-\sigma)$.

Because domestic agents are risk averse and face idiosyncratic uncertainty about their type, they can benefit from pooling their resources. As in Diamond and Dybvig, Chang and Velasco explore how this superior equilibrium can be achieved by a bank issuing demand deposits subject to a sequential servicing constraint. As a first step in the analysis, consider the problem faced by a planner who cannot observe the individual's type. Under these circumstances, an incentive compatibility constraint has to be satisfied for type B consumers

to reveal their true type in period 1.[4] Letting b_0 and b_1 denote net foreign borrowing in periods 0 and 1 respectively, k the amount invested in the illiquid technology, and l the amount of domestic investment liquidated in period 1, the problem is to maximize expected utility as given by Equation (14) subject to:

$$k \leq b_0 + e, \tag{15}$$

$$\lambda c_1 \leq b_1 + rl, \tag{16}$$

$$(1-\lambda)c_2 + b_0 + b_1 \leq R(k-l), \tag{17}$$

$$b_0 \leq f, \tag{18}$$

$$b_0 + b_1 \leq f, \tag{19}$$

$$c_2 \geqslant c_1, \tag{20}$$

$$c_1, c_2, k, l \geqslant 0. \tag{21}$$

With the exception of Equation (20), these constraints are self-explanatory. Equation (20) is the incentive compatibility constraint referred to earlier. It ensures that type B agents have no incentive to misrepresent their type.

Because the economy faces no aggregate uncertainty, the solution to this problem will imply no liquidation of domestic investment to finance period 1 consumption, because it is cheaper to finance such consumption by borrowing abroad. Thus, the solution must imply $l = 0$ and $\lambda c_1 = b_1$. Because external borrowing is optimal in period 1, constraint (18) cannot bind, and (19) must hold as an equality that determines b_0. From Equation (17), these considerations imply that:

$$R\lambda c_1 + (1-\lambda)c_2 = Re + (R-1)f = Rw, \tag{22}$$

where $w = e + f(R-1)/R$ is a measure of the economy's wealth. Maximizing expected utility (14) subject to this constraint yields the optimal consumption levels:

$$\lambda c_1^* = \theta w, (1-\lambda)c_2^* = (1-\theta)Rw, \tag{23}$$

where $0 \leq \theta \equiv [1 + (1-\lambda)/\lambda R^{(\sigma-1)/\sigma}]^{-1} \leq 1$. It can be readily verified that this solution satisfies the incentive compatibility constraint (20).

Chang and Velasco argue that this equilibrium can be generated by a situation in which in period 0 domestic agents surrender their endowments and their capacity for foreign borrowing to a bank, which in return agrees to invest k in the domestic technology, to borrow b_0 and b_1 abroad respectively in periods 0 and 1, and to pay a return to depositors equal to c_1^* if funds are withdrawn in period 1—at least until the bank's resources are exhausted—and c_2^* if they are withdrawn in period 2. If type A depositors each withdraw c_1^* in period 1 and type B depositors leave their funds in the bank, the resulting equilibrium satisfies the conditions listed above and is a social optimum.

[4] The incentive compatibility constraint is automatically satisfied for type A consumers, who have no incentive to be paid in period 2.

The problem is that, as in Diamond and Dybvig, this is not the only possible equilibrium. In particular, a bank panic, in which withdrawals exceed the resources available to the bank in period 1, resulting in the liquidation of the bank, is also a possible equilibrium. An important question in this regard concerns the conditions under which the bank's resources may be exhausted by period 1 withdrawals. In principle, the bank could meet such withdrawals by borrowing abroad or by liquidating domestic investments. If the bank is committed to servicing its external borrowing, then the maximum amount of domestic investment it can liquidate is given by:

$$l^+ = Rk^* - f, \tag{24}$$

so it will be unable to fulfill its obligations in period 1 if:

$$z^+ = c_1^* - (b_1 + rl^+) > 0. \tag{25}$$

This condition holds when the bank's liquid assets, in the form of external funds and the liquiditation value of domestic investments, which together sum to $b_1 + rl^+$, fall short of its demand deposit liabilities c_1^*. If it holds, a bank run in which a sufficient number of type B depositors seek to withdraw funds in period 1 so as to exhaust the bank's resources is also a rational expectations equilibrium, because in the event of a run, type B depositors who are *not* successful in withdrawing funds in period 1 will receive nothing in period 2.

The conditions for a successful run are more likely to be met if a "sudden stop" of capital inflows accompanies the run. To see this, assume that the bank feels obliged to service only its period 0 external debt—and not its period 1 external debt—in the event of a run. If so, the maximum amount of domestic investment that it can liquidiate increases to:

$$l^a = Rk^* - b_0 = Rk^* - (f - b_1) = l^+ + b_1. \tag{26}$$

But the critical liquidity condition now becomes:

$$z^a = c_1^* - rl^a = c_1^* - r(l^+ + b_1),$$

that is

$$z^a = z^+ + (1-r)b_1 > 0. \tag{27}$$

Because $z^a > z^+$, this condition is more likely to be met. The implication of this analysis is that if a run is accompanied by a sudden stop of capital inflows, the conditions for a run to be an equilibrium are more likely to be met. Thus, a sudden stop of capital inflows could trigger a run on the bank. But the

converse is also true: a bank run makes a sudden stop of capital inflows more likely, because a run makes it less likely that new external borrowing will be serviced by the bank. Thus, domestic bank runs and "sudden stops" of capital flows (as discussed in the previous chapter) are complementary.[5]

2.3 | The Flood–Marion Joint Distribution Approach

Other models of the joint occurrence of banking system and currency collapses include Buch and Heinrich (1999) and Flood and Marion (2004). In the Buch–Heinrich model, as in the model by Velasco (1987), there is a close link between the two types of crises. A banking collapse brings forward the time of a currency collapse. An adverse shock to bank asset returns lowers the net worth of banks and increases their cost of foreign borrowing. Because the government is already monetizing a fiscal deficit and losing international reserves, the decline in foreign borrowing speeds up the inevitable collapse of the fixed exchange rate.

In Flood and Marion (2004), by contrast, bank and currency collapses need not occur together or sequentially. they consider a small open economy with a fixed exchange rate and a banking system that incurs foreign-currency-denominated liabilities. There is a single, economy-wide real shock that affects returns on bank assets, the demands for assets and government financing. A bank collapse occurs when banks' liabilities exceed their assets, whereas a currency collapse occurs when currency speculators rush to purchase all the government's international reserves committed to the defense of the fixed rate. Speculators act the moment the shadow exchange rate exceeds the fixed rate, as in the standard Krugman–Flood–Garber model (see Chapter 15). Both bank and currency collapses result from bad shocks to fundamentals, and they are therefore related; but because these shocks affect differently the two conditions for collapse, banking and currency crises do not always occur together.

3 | Asymmetric Information and Opportunism

The Diamond-Dybvig framework adopted up to now perceives the social role of banks as allowing the economy to undertake highly productive but illiquid investments despite the fact that individual savers have reason to value liquidity. Banks essentially substitute for missing insurance markets. An alternative perspective on the social role of banks views them instead as social innovations to solve information and incentive, rather than insurance, problems.[6] From this perspective, rather than being an unfortunate byproduct

[5] Vaugirard (2007) extends the Chang–Velasco framework to study contagious effects of bank runs.

[6] For an early overview, see Gertler (1988); see also Freixas and Rochet (1997).

of illiquidity, bank runs actually play the socially useful role of reducing principal–agent problems between banks and their depositors.

The key insight of this alternative analytical perspective is that in the presence of asymmetric information and opportunistic behavior, financial transactions are costly. The costs involved are of various types, and are incurred at every step of the financial transaction, from the initial coming together of the two parties to the transaction to its eventual liquidation. First, when information is asymmetric, lenders and borrowers have to search for each other. Matching the two sides of a financial transaction thus involves incurring brokerage costs. Second, in the presence of asymmetric information, adverse selection requires a potential lender to incur loan evaluation costs. Third, the combination of asymmetric information and opportunistic behavior creates principal–agent problems after money has changed hands between lenders and borrowers, because borrowers will have an incentive to use the funds they have acquired to pursue their own interests, rather than those of the lenders. This requires the incurring of monitoring costs. Finally, because contracts are not self-enforcing in a world of opportunistic behavior, financial transactions also involve incurring contract enforcement costs. All of these costs create a wedge between the interest rate paid by borrowers and that received by lenders, known as the external finance premium.

A second key observation is that all such costs are likely to have a substantial fixed component (that is, a component that is independent of the amount of money being transacted). The implication is that the external finance premium would be very high if financial intermediation were conducted by individuals. Institutions that specialize in financial intermediation, however, can achieve lower unit costs by taking advantage of economies of scale in each step of the process of financial intermediation (bringing lenders and borrowers together, evaluating loans, monitoring them, and enforcing loan contracts), as well as of economies of scope among these activities. As a result, specialized firms can intermediate between borrowers and lenders at significantly lower cost than individuals can. The social contribution of such firms, therefore, is to lower the external finance premium.

This, then, is what banks do. However, because the key advantage of banks is that they can make information-intensive loans at lower costs than individuals, banks will necessarily possess more information about the quality of the assets in their portfolios than any outside agents, including banks' own depositors. Thus, bank's depositors themselves face an adverse selection problem as lenders. Moreover, banks as borrowers are in a principal–agent relationship with their depositors, and they face the same incentives to act in their own interest once entrusted with others' money as other borrowers do. Thus, bank depositors also have to solve a moral hazard problem. This problem is compounded by the fact that monitoring the bank is a public good: as long as monitoring by some depositors keeps the bank—as agent—serving the needs

of its depositors—as principals—all depositors benefit, whether they monitor or not.

The issuance of liquid bank liabilities with a sequential service constraint addresses the adverse selection and moral hazard problems confronting bank depositors. The availability of deposits on demand enables depositors to quickly penalize a bank that is perceived to be misusing depositors' money by cutting off the bank's access to funds. The sequential servicing constraint, in turn, addresses the public good character of monitoring. It preserves an incentive for individual depositors to monitor banks, because only well-informed depositors who get their money out early are likely to avoid losses if the bank underperforms. Finally, banking crises that wipe out the bank's equity are the ultimate penalty for misallocation of depositors' funds. From this perspective, then, liquid liabilities, sequential servicing, and bank runs are the enforcement devices through which banks are induced to act in their depositors' interest and which therefore encourage depositors to entrust their savings to banks.[7]

This does not mean, of course, that bank runs are socially beneficial from this perspective. Though the threat of a run that causes a bank to become insolvent plays the socially useful role of aligning the interests of the owners of the bank with that of its depositors, a run that resulted in bank insolvency would nonetheless be destructive from a social perspective. Not only may highly productive but illiquid assets be liquidated, as in the Diamond–Dybvig model, but the failure of a bank also means the loss to society of the private information the bank had acquired about its debtors.

For this reason, last-resort lending and/or deposit insurance arrangements continue to offer social benefits. However, from the asymmetric information perspective these benefits must be weighed against some potentially serious costs (see Santos, 2006). Specifically, while such arrangements may reduce or even eliminate the likelihood of a costly panic, they also reduce the incentives for depositors to monitor and may thus aggravate moral hazard problems in banking. The upshot is that the presence of such arrangements creates a case for the government to act as delegated monitor, through the regulation and supervision of banks to prevent moral hazard lending.

4 | Determinants of Banking Crises: Evidence

There is no necessary conflict between the views of banks as social innovations to reduce the costs of financial intermediation arising from asymmetric information and opportunistic behavior, on the one hand, and as mechanisms for maturity transformation, on the other. The liquid liabilities that banks are induced to issue to facilitate monitoring by depositors are also attractive to depositors because they satisfy liquidity needs. At the same time, the pooling

[7] For elaboration, see Calomiris and Gorton (1989).

of many liquid liabilities allows banks to reduce exposure to liquidity risk and thus, in undertaking information-intensive lending, to include in their asset portfolios relatively illiquid projects with high expected returns. This eclectic perspective, however, leaves banks with assets that are simultaneously opaque (at least from the viewpoint of outsiders) as well as relatively illiquid, and with highly liquid liabilities that are subject to a sequential servicing constraint. From this perspective, it may not be surprising that banking crises have become relatively frequent events after domestic financial systems have been liberalized in developing countries. In this section, we review some of the international evidence on the factors that have caused such crises. Three types of evidence are examined: episodic cross-country studies, results from "early warning" indicators, and multivariate econometric eveidence.

4.1 | Episodic Cross-Country Evidence

An early study of the causes and effects of banking crises in developing countries was conducted by Sundararajan and Baliño (1991), who examined the experiences of seven developing countries, including the Southern Cone crises in Argentina during 1980–1982, Chile in 1981–1983, and Uruguay in 1982–1985, as well as those in the Philippines during 1983–1986, Thailand in 1984–1986, Spain over the period 1978–1983, and Malaysia in 1985–1986. Each of these episodes was preceded by domestic financial liberalization, though the extent of liberalization and the time elapsed between the change in policy regime and the emergence of the banking crisis varied widely among them. In all of them, the crises resulted in the generalized insolvency of domestic banks.

Because nonperforming loans grew sharply just prior to and during each of these crises, the authors concluded that none of them could be interpreted as a self-fulfilling bank panic, that is, these crises were caused by deterioration in fundamentals. In all of these cases, the crisis occurred after a period of rapid economic growth, with substantial variations in relative performance among sectors, and followed by a slowdown. Adverse movements in asset prices (real estate and stocks) were important elements in some cases, but not all. However, consistent with the subsequent findings of Kaminsky and Reinhart (1999), the outbreak of these crises was associated with major external shocks and balance-of-payments problems. Sharp adjustments in exchange rates and interest rates, reflecting exchange market pressures, occurred around the time of the crises, though in some cases the currency crisis came before, and in others after, the banking crisis. In most countries, however, external imbalances were severe just before the banking crisis. However, in contrast with the findings of Gorton for the National Banking Era in the United States, these crises happened both with and without deposit insurance. Full deposit insurance was abandoned in Argentina in November 1979, and in the

Philippines the deposit insurance agency had insufficient funds, causing the settlement of claims to be delayed.

There was a significant shift from deposits into currency and/or a decrease in the interest elasticity of currency demand following the crises in all of these countries. As a result, there were sharp reductions in money multipliers in Argentina, the Philippines, Spain, and Uruguay, though not in Thailand and Chile (in Thailand this is because the crisis affected mainly finance companies, rather than banks). The crises were associated with strong reductions in GDP growth and an initial deceleration of inflation, though the latter was subsequently reversed in some cases. Confidence was restored by last-resort lending (which was used in all of these cases), intervention of some of the troubled institutions, and the reimposition of deposit insurance. Last-resort lending, however, soon gave way to long-term lending at concessional rates, because of the generalized insolvency of financial institutions. Thus, governments wound up subsidizing failed institutions, as modeled by Velasco (1987). The losses to depositors were minimal in all cases (though Argentina and Thailand permitted some losses) and the fates of troubled banks differed across countries (they were liquidated in some cases, merged or restructured in others, and nationalized, or subsidized in still others). Bank borrowers were assisted with financial support, technical assistance, and debt-equity conversions.

A more comprehensive study that provided a data set used in many subsequent studies is that of Caprio and Klingebiel (2003). Defining a systemic banking crisis as occurring when the banking system reports nonperforming loans in excess of 5 percent of total loans, these authors identified a total of 112 systemic banking crisis episodes in 88 countries from 1975 to 2001. As did Baliño and Sundararajan, they found that the pre-crisis period in these cases tended to be characterized by unusually rapid credit growth as well as macroeconomic volatility (measured in this case by variability in GDP growth, inflation, and the terms of trade). Even more prevalent than macroeconomic problems, however, were microeconomic factors such as poor supervision and regulation of banks, political interference, connected lending, and poor bank management. This provides strong support for the empirical importance of the asymmetric information and opportunisitc behavior perspective of Section 3.

4.2 | Signaling Approach

Two dominant empirical approaches have been adopted for the more systematic investigation of the factors driving banking crises in developing countries: a "signaling" approach, and a multivariate approach typically based on the estimation of logit or probit regressions.

The signaling approach consists of trying to identify "early warning indicators" of future banking sector difficulties. The Kaminsky–Reinhart "twin crises" paper cited previously pioneered this approach in the context

of developing-country banking crises. The approach consists essentially of specifying a comprehensive list of possible crisis determinants suggested by theory, and examining the extent to which unusual movements in each of these variables help to predict a future banking crisis. More concretely, Kaminsky and Reinhart considered whether each potential crisis determinant crossed a critical threshold in the period before the crisis. If it did, it was interpreted as emitting a signal of a future crisis. The critical threshold for each variable was chosen empirically, so as to minimize the signal-to-noise ratio within the sample for that variable (that is, the ratio of correct predictions to false positives). Kaminsky and Reinhart found that the most reliable early warning signals of impending crises were emitted by the behavior of the real exchange rate (an extreme real appreciation portends a future banking crisis), of stock prices (an extreme decline signals a future crisis), and the money multiplier (again, an extreme decline signals an upcoming crisis).

Kaminsky (1999) further developed the signaling approach, by combining the information contained in several indicators in a manner that gives relatively more weight to the more effective indicators. Her approach consisted of constructing a composite indicator consisting of the number of indicators that emit a positive signal at any moment of time, weighted by the signal-to-noise ratio of each indicator. The composite indicator turned out to be better than any single indicator at predicting banking crises, though it displayed a greater tendency for false positives. Further extensions are provided by Edison (2003), but with mixed results.

4.3 | Econometric Investigations

There have been a large number of econometric investigations of the empirical determinants of banking crises in recent years, typically applying logit or probit estimation to a qualitative crisis–non-crisis-dependent variable. The pioneering study was by Demirgüç-Kunt and Detragiache (1998). In this paper the authors sought to explain the empirical determinants of banking crises using annual data drawn from samples of 45–65 countries (depending on data availability for specific equation specifications), over the period 1980–1994. Demirgüç-Kunt and Detragiache classified a given year as a crisis observation if the ratio of nonperforming loans to total assets in the banking system exceeded 10 percent, if there was a bank rescue operation with fiscal costs in excess of 2 percent of GDP, if there were widespread bank nationalizations specifically as the result of banking sector problems, whether extensive bank runs, deposit freezes, or prolonged bank holidays took place in that year, or if generalized deposit insurance was enacted in response to such problems. On the basis of these criteria, they classified 31 out of the 546 observations in their sample as banking crisis episodes.

Using a logit procedure, they investigated the factors that affected the probability that any given observation in the sample would be classified as

a crisis observation. Among macroeconomic variables, slow domestic GDP growth, poor performance of the country's terms of trade, and high domestic nominal and real interest rates tended to be associated with banking crises, but exchange-rate depreciation and fiscal variables were not. There was weak evidence that rapid growth of credit to the private sector—such as would emerge in a liberalized environment with inappropriate regulation of banks—predicted subsequent crises. Consistent with the Chang–Velasco emphasis on bank vulnerability to depositor and external creditor panic, a high ratio of M2 to the central bank's stock of foreign exchange reserves increased the likelihood of a crisis. Finally, Demirgüç-Kunt and Detragiache found that a low value of the law and order index that they used to indicate the adequacy of the domestic institutional environment helped predict subsequent crises, and that the presence of deposit insurance *increased* the probability of a crisis in their sample. This result was confirmed in a subsequent study by the authors, based on a sample of sixty-one countries over the period 1980–1997 (Demirgüç-Kunt and Detragiache (2002).

A similar study by Hutchinson and McDill (1999) supplemented a statistical study of determinants of banking crises in a large sample of countries with an examination of the "typical" time series behavior of macroeconomic variables and financial variables in crisis countries. They found that in crisis countries, as compared to the others, the pre-crisis period was characterized by a faster rate of currency depreciation, a higher rate of inflation, and a higher ratio of M2 to foreign exchange reserves. Stock prices were somewhat higher in crisis countries, but fiscal performance showed no noticeable differences. In economies that had crises, real output growth experienced a boom before a crisis, but slowed gradually prior to the crisis. It dropped sharply at the onset of the crisis, and gradually recovered. Credit growth was strong prior to the crisis, contracted during the first year, and then rebounded slowly. Exchange-rate depreciation jumped significantly at the onset of the crisis, and stock prices dropped markedly. In their formal statistical analysis, Hutchinson and McDill found that slower growth of real GDP and lower stock prices all increased the likelihood of a subsequent crisis, as did financial liberalization, deposit insurance, and their interaction. By contrast, greater central bank independence reduced susceptibility to banking crises.

One problem with studies of this sort is that, because they typically start with a large number of possible crisis determinants identified on an ex ante basis and identify the set of critical determinants on the basis of theoretically correct signs and statistical significance within a specific sample, their robustness to variations in the set of included variables and the specific sample chosen is difficult to ascertain. Eichengreen and Arteta (2002) focused on the robustness of alternative predictors of banking crises in developing countries. They used the Caprio–Klingebiel crisis dataset to generate the dependent variable for a probit regression to explain crisis incidence. In accordance with much of the empirical literature on banking crises, they found that domestic financial liberalization, rapid prior credit expansion, and a low ratio of central bank foreign exchange reserves to broad money have been the most robust predictors of banking crises in developing countries. This is consistent not just with both of the perspectives on the role of banks reviewed above, but also with the importance of "twin crises," because the reserve/broad money ratio is an indicator of external vulnerability. Despite this, and somewhat surprisingly, Eichengreen and Arteta did not find a stable relationship between the exchange-rate regime and the incidence of banking crises.

Two other findings in the Eichengreen–Arteta study are worth mentioning in association with the issues analyzed in this chapter. First, regarding the role of financial liberalization, as already mentioned, domestic financial liberalization was associated with an increased susceptibility to crises. By contrast, Eichengreen and Arteta did *not* find that opening up the capital account contributed to increasing the likelihood of banking crises, at least on its own. However, capital account liberalization did increase the effect of domestic financial liberalization on the probability of a banking crisis. Second, with respect to deposit insurance, Eichengreen and Arteta obtained results directly opposite to those of both Demirgüç-Kunt and Detragiache and Hutchinson and McDill: the presence of deposit insurance coverage *reduced* the likelihood of banking crises in their sample. Eichengreen and Arteta attributed the difference in results to their use of a larger developing-country sample than earlier investigators. However, they did find, consistent with the asymmetric-information perspective on the role of banks, that the interaction of deposit insurance and weak institutions—interpreted as indicating a weak regulatory and supervisory structure—increased the likelihood of banking crises.

More recently, Bussière and Fratzscher (2006) proposed a new early-warning system for predicting financial crises, based on a multinomial logit model. They argue that commonly used approaches, which use binomial discrete-dependent-variable models, are subject to a post-crisis bias—which arises because no distinction is made between tranquil periods, when economic fundamentals are largely sound and sustainable, and crisis/post-crisis periods, when economic variables go through an adjustment process before reaching a more sustainable level or growth path. A multinomial logit model, which allows distinguishing between more than two states, allows a substantial improvement in the ability to forecast financial crises for a set of twenty countries over the period 1993–2001.