Understanding the Korean and Thai currency crises

Craig Burnside, Martin Eichenbaum, and Sergio Rebelo

Introduction and summary

In late 1997, Southeast Asia was rocked by banking and currency crises. While dramatic in scope and intensity, this episode was only the latest in a series of "twin crises." Other prominent examples include Argentina (1980), Chile (1981), Uruguay (1981), Finland (1991), Sweden (1991), and Mexico (1994). In this article, we review and interpret the recent Korean and Thai experiences, focusing on the pivotal role of unfunded contingent government liabilities. We concentrate on the Korean and Thai cases both because their crises were severe and because neither country appeared to be a likely candidate for a currency crisis, at least not from the perspective of standard economic models.

In addition to being of independent interest, the lessons learned from the Korean and Thai episodes should be useful in predicting and averting future twin crises.[1] In a nutshell, these lessons are as follows. First, twin crises are likely to erupt in countries whose governments have large *prospective* deficits stemming from guarantees to failing financial sectors. Such guarantees typically insure creditors—both domestic and foreign—against realizing large losses when financial institutions that they have lent money to become insolvent or go broke. Second, past deficits are, at best, a noisy indicator of how large a government's prospective deficits are. Accurately measuring the latter requires a careful analysis of the nature of a government's guarantees and the probability that those guarantees will be called upon. It may never be possible to predict precisely *when* a twin crisis will occur. But more accurate measures of prospective deficits are likely to be helpful in predicting *where* twin crises will occur. Finally, to avoid currency crises, governments must have credible plans to finance contingent liabilities with credible, explicit fiscal reforms. Such reforms include concrete measures to cut government expenditures or raise taxes.

In the body of the article, we provide the empirical background for our analysis. We begin by motivating empirically the importance of past banking crises as a source of government liabilities. We then briefly review the salient features of the recent crises in Korea and Thailand. These can be summarized as follows.

1. Both currency crises were difficult to predict on the basis of standard economic indicators, such as inflation rates, monetary growth rates, or past government deficits.
2. Neither banking crisis was difficult to anticipate, certainly not if one used publicly available information about the market value of financial firms in Korea and Thailand.
3. When the crises came, they came with a vengeance. The Korean won and Thai baht rapidly depreciated by over 50 percent and 80 percent, respectively, vis-à-vis the dollar before partially rebounding in value. In addition to the large social costs associated with severe recessions, the crises saddled the Korean and Thai governments with very large liabilities. These arose both from their implicit guarantees and the need to restructure their respective banking systems. As we discuss below, these costs are now estimated to exceed 25 percent of Korea's and Thailand's gross domestic product (GDP).
4. After the crises, the rates of inflation and money growth rose in both countries, though not by nearly as much as the rates of depreciation of the won and

Craig Burnside is a senior economist at the World Bank. Martin Eichenbaum is a professor of economics at Northwestern University, a research associate of the National Bureau of Economic Research (NBER), and a consultant to the Federal Reserve Bank of Chicago. Sergio Rebelo is a professor of economics at Northwestern University and a research associate of the NBER.

the baht. The rise in the price of tradable goods was much larger than the rise in the price of nontradable goods.

Later, we provide an explanation of the way in which prospective deficits could have caused the currency crises. The basic idea is that the Korean and Thai financial sectors were in trouble prior to the currency crises and investors knew this. Given the Korean and Thai governments' implicit guarantees to their banking sectors, market participants revised upwards their estimates of future government deficits. Given the difficulty of raising tax revenues or lowering government expenditures in the wake of a severe banking crisis, private agents expected that future deficits would be financed, at least in part, by higher seigniorage revenues. This led to expectations of higher future inflation rates and a reduction in the demand for domestic currency. The resulting drain on official reserves of foreign currency triggered the currency crises. Finally, because many financial institutions did not hedge the currency mismatch in their assets and liabilities, the currency crises exacerbated the initial banking crises and raised the associated fiscal costs.

We articulate these ideas using a simplified version of the model in Burnside, Eichenbaum, and Rebelo (1999). In versions of the model roughly calibrated to Korean data, a speculative attack occurs *after* the information about higher future deficits arrives but *before* the new monetary policy is implemented. So the model is consistent with the idea that the fixed exchange rate regimes in Korea and Thailand collapsed after agents understood that the banks were failing, but before governments actually started to monetize their deficits. Thus the model can account for facts 1 and 2 discussed above: The banking crises were predictable but standard indicators of bad government policy—high deficits, high inflation rates, and rapid money growth—were not observed prior to the crises.

While successful on a number of important dimensions, the benchmark model suffers from several shortcomings. First, it implies a larger rate of inflation than actually occurred after the crises. Second, the model predicts that the domestic Consumer Price Index (CPI) moves one to one with the exchange rate. So it is inconsistent with the fact that the rise in measured inflation was smaller than the rate of depreciation in the won and baht. In addition, since the benchmark model assumes that all goods are tradable, it cannot address the post-crises differential rates of inflation in traded and nontraded good prices. We briefly discuss ongoing research that shows how the benchmark model can be modified to overcome these shortcomings.[2] From the perspective of this article, the key point is that the modifications do not alter the model's message about the connection between prospective deficits and currency crises.

Finally, we turn to the issue of which countries might be at risk for the kind of twin crises experienced by Korea and Thailand. Here we reproduce and discuss Standard and Poor's recent estimates of governments' contingent liabilities to financial sectors. These estimates reveal that a government's exposure to future contingent liabilities is not well estimated by conventional debt measures. Since future deficits can be just as important as past deficits in triggering currency crises, policymakers who focus only on conventional debt measures do so at their peril. When the storm comes, they will be taken by surprise. Our research suggests that they need not be, provided that they spend more resources on measuring the extent of their contingent liabilities.

Basic facts

Our analysis of recent events in Southeast Asia leans heavily on the notion that the Thai and Korean governments faced serious fiscal problems because of implicit, unbudgeted guarantees to their banking sectors. In this section we accomplish two tasks. First, we provide some evidence on the fiscal implications of banking crises in a variety of countries. Second, we briefly review the twin crises and their aftermath in Korea and Thailand.

Fiscal costs of past banking crises

Table 1 summarizes estimates of the fiscal costs of banking crises, as a percentage of GDP, taken from the studies summarized by Frydl (1999). Table 2 contains estimates of the costs of the recent banking crises in Southeast Asia, taken from *Standard and Poor's Sovereign Ratings Service*.[3]

Comparing tables 1 and 2 we see that, while large, the magnitude of the bailouts in Southeast Asia was by no means unprecedented (see, for example, table 1 on the costs of the Argentinian, Chilean, and Uruguayan banking crises in the 1980s). No doubt there is substantial uncertainty about the precise fiscal cost of any given banking crisis. Still, two things are clear. First, banking crises occur with depressing regularity. And second, when they happen, they impose large fiscal costs on governments.

Brief review of the twin crises in Korea and Thailand

Here, we briefly review the prelude and aftermath of the twin currency–banking crises in Thailand and Korea. In addition to providing general background

for our analysis, we substantiate the claims summarized as facts 1 through 4 in the introduction.

The currency crises

Figures 1 and 2 display the exchange rates of the baht and the won, where the exchange rate is defined as the price of a dollar in units of local currency.[4] It is evident that Thailand and Korea experienced severe currency crises in the latter part of 1997. The crises were severe in the sense that both currencies underwent very large depreciations in a short period of time: The

TABLE 1

Fiscal cost of banking crises, studies surveyed by Frydl (1999)

		Caprio and Klingebiel[a] (July 1996)		Lindgren et al.[b] (mid-1996)		Dziobek & Pazarbasioglu[c] (December 1997)	
Group	**Country**	**Period**	**Cost[d]**	**Period**	**Cost[d]**	**Year**	**Cost[d]**
Africa	Benin	1988–90	17	1988			
	Cote d'Ivoire	1988–91	25	1988–90		1991	13
	Ghana	1982–89	6	1983–89	3	1989	6
	Guinea	1985	3	1980–85			
	Mauritania	1984–93	15	1991–93		1993	15
	Senegal	1988–91	17	1983–88			
	Tanzania	1987	10	1988–	6.5	1992	14
	Zambia	1995	1.4	1994	3	1995	3
Asia	Bangladesh	Late 1980s–		1980s	4.5		
	Indonesia	1994	1.8	1992–	2	1994	2
	Malaysia	1985–88	4.7	1985–88	4.7		
	Philippines	1981–87	3	1981–87	13.2	1984	4
	Sri Lanka	1989–93	5	early 1990s			
	Thailand	1983–87	1.5	1983–87			
Latin America	Argentina	1980–82	55.3	1980–82	4		
	Argentina	1995		1995		1994	0.3
	Bolivia			1994–	4.2		
	Brazil	1994–95	7.5	1994–			
	Chile	1981–83	41.2	1981–87	29	1983	33
	Colombia	1982–87	5	1982–85			
	Mexico	1995	13.5	1994–	6.5	1994	13.5
	Peru			1983–90		1991	0.4
	Uruguay	1981–84	31.2				
	Venezuela	1994–95	18	1994–	17	1994	17
Mideast and North Africa	Israel	1977–83	30	1983–84			
	Kuwait	1980s		Mid-1980s		1992	45
	Turkey	1982–85	2.5	1982			
	Turkey			1994	1		
Transition economies	Bulgaria	1990s	14	1991–			
	Czech Rep.			1991–	12		
	Estonia	1992	1.4	1992–95	1.8		
	Hungary	1991–95	10	1987–	9	1993	12.2
	Kazakhstan			1991–95	4.5	1995	
	Poland	1990s	$1.7bil	1991–		1993	5.7
	Slovenia	1990s	$1.3bil	1992–94			
Advanced OECD	Finland	1991–93	8	1991–94	8.4	1991	9.9
	France	1994–95	$10bil	1991–95	0.6		
	Japan	1990s	$100bil	1992		1995	
	Norway	1967–89	4	1987–93	3.3		
	Spain	1977–85	16.8	1977–85	5.6	1980	15
	Sweden	1991	6.4	1990–93	4	1991	4.3
	United States	1984–91	3.2	1980–92	2.4		

[a]Dates indicate the period of the crisis episode. Dash indicates that the crisis was ongoing at the date of publication.
[b]Dates indicate the period of the banking sector difficulties. Dash indicates that the difficulties were ongoing at the date of publication.
[c]Date indicates year of onset of restructuring action.
[d]Percent of GDP, unless stated otherwise.
Note: OECD is Organization for Economic Cooperation and Development.

TABLE 2

Costs of restructuring and recapitalizing banking system

	Percent of GDP	Date of estimate
Indonesia	65	November 1999
Korea	24	December 1999
Malaysia	22	December 1999
Thailand	35	June 1999

Note: Dates refer to date of issue of source country reports.
Source: *Standard and Poor's Sovereign Ratings Service*, various country reports.

value of the baht relative to the dollar declined by over 50 percent between June 1997 and January 1998; and the value of the won relative to the dollar declined by over 48 percent between October 1997 and January 1998.[5]

The banking–financial sector crises

Both Korea and Thailand experienced severe banking–financial sector crises that began *before* their currency crises. Corsetti, Pesenti, and Roubini (1999) report that pre-crisis nonperforming loan rates were 19 percent in Thailand and 16 percent in Korea, or roughly 30 percent and 22 percent of GDP, respectively. That being said, the currency crises certainly exacerbated the financial crises.[6] According to J.P. Morgan (1998), as of June 1998, the rate of nonperforming loans in both Korea and Thailand had risen to roughly 30 percent. By June 1999, the cost of recapitalizing and restructuring the banking system in Thailand reached 35 percent of GDP (see table 2). As of December 1999, the corresponding cost in Korea had reached 24 percent of GDP.

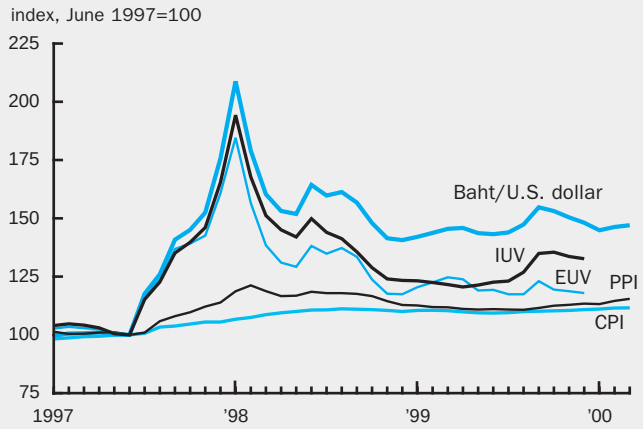
Was the public aware of the banking crises before the currency crises? In our view the answer is yes. First, proprietary information from some bank rating services and investment banks had raised doubts about the health of the local banks. Second, the market value of the banking and financial sectors in Thailand and Korea declined precipitously *before* the currency crisis hit. Table 3, extracted from Burnside, Eichenbaum, and Rebelo (1999), reports indexes of the stock market value of publicly traded banks and financial firms in Thailand and Korea. In addition, we report the analog value of the commercial and manufacturing sector in Thailand and Korea, respectively.[7] The column labeled "Pre-crisis peak" pertains to the date of the peak value of the banking sector in the two countries. Three features of table 3 are worth noting. First, in both countries, the value of the banking and finance sectors fell by large amounts before the currency crises. For example, in the period between the pre-crisis banking peak and the day immediately prior to the currency crisis, the value of the Thai and Korean finance sectors fell by 92 percent and 52 percent, respectively. Second, in the case of Thailand, the value of the financial sector fell by a large amount relative to the decline in the commerce sector. In the case of Korea, the manufacturing sector index actually rose up to the day before the crisis. So the decline in the value of the financial sectors did not simply reflect a decline in the overall stock market. Markets seemed particularly concerned about the financial sector.

Both Thailand and Korea had low inflation rates prior to their currency crises. Over the two previous years, the CPI in Thailand and Korea rose at annual rates of 5 percent and 4.6 percent, respectively,[8] giving no hint of the currency crises to come.

Figures 1 and 2 display measures of the CPI, the Producer Price Index (PPI), and indexes of export and import prices in the periods immediately before and after the currency crises. In both countries overall consumer and producer price inflation was moderate in the aftermath of the devaluation. For example, in Thailand, the CPI rose roughly 11 percent between June 1997 and June 1998, and only rose

FIGURE 1

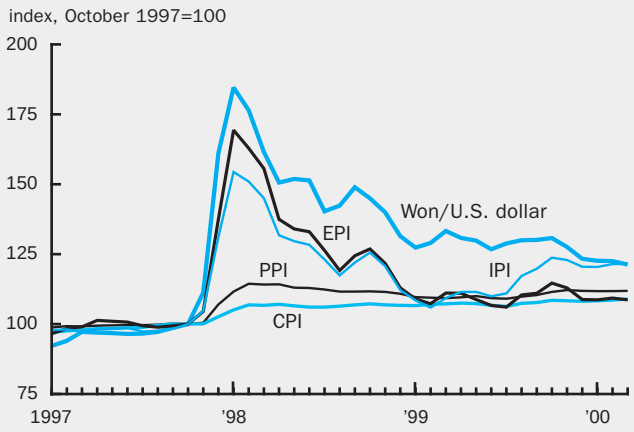
Prices in Thailand



Notes: IUV is import unit value; EUV is export unit value; PPI is Producer Price Index; and CPI is Consumer Price Index.
Source: "Data bank" at www.bot.or.th.

FIGURE 2

Prices in Korea



Notes: EPI is Export Price Index; IPI is Import Price Index; PPI is Producer Price Index; and CPI is Consumer Price Index.
Source: "Statistics" at www.bok.or.kr and Datastream.

a further 1 percent by March 2000. In Korea, the CPI rose 7.2 percent between October 1997 and October 1998. Also notice that import and export prices moved much more in response to movements in the exchange rate (see figures 1 and 2) than either the CPI or the PPI.

So, the behavior of inflation after the crises can be summarized as follows. First, in both Korea and Thailand, there was a moderate rise in inflation, measured using either the CPI or the PPI. But the rise in overall inflation was much less than the rate of depreciation in the respective exchange rates. Second, tradable goods prices rose substantially, with the rate of increase being similar in magnitude to the rate of depreciation of the won and the baht. An important issue we return to later is how to account for these two facts.

Fiscal deficits and debt

Prior to their crises, Thailand and Korea had been running fiscal surpluses and had fairly modest debt to GDP ratios.[9] The overall fiscal position of the Thai government, inclusive of interest payments, was positive, with a surplus of close to 3 percent of GDP in 1994 and 1995 and 0.7 percent of GDP in 1996. The amount of government debt held by domestic residents was very small before 1997, while public sector external debt was roughly 10 percent of GDP before 1997. In Korea, the government's overall fiscal position and primary balance (government expenditures minus tax revenues) were always in surplus, though close to zero, in 1994–96. The government's domestic debt at the end of 1996 was just 7.6 percent of GDP, while consolidated public sector external debt was just 6.1 percent of GDP.

Since the crises, both countries have been running fiscal deficits and have accumulated substantial amounts of new debt. By the end of 1998, the Thai government's domestic debt had jumped to almost 10 percent of GDP, while external public sector debt rose to almost 25 percent of GDP. In Korea, the government's domestic debt rose to 19.1 percent of GDP by the end of 1998, while public sector external debt rose to 11.4 percent of GDP.

We conclude that 1) traditional measures of government deficits or debt gave no indication of the currency crises to come in Korea and Thailand, and 2) the debt situations of the governments in both countries appeared radically different before and after the twin crises.

TABLE 3

Stock market indexes in Thailand and Korea

	Pre-crisis peak	Day before crisis		
Thailand	**1/4/94**	**6/30/97**	**7/31/98**	**5/2/00**
Banking	221.6	100	23.4	44.0
Finance	1,286.7	100	36.0	60.2
Commerce	318.4	100	59.6	76.3
Korea	**8/3/91**	**10/28/97**	**7/31/98**	**5/2/00**
Banking	214.2	100	28.6	27.2
Finance	206.3	100	29.4	32.2
Manufacturing	79.8	100	47.6	111.0

Note: Indexes reflect values in local currencies.
Source: Bloomberg and Burnside, Eichenbaum, and Rebelo (1999).

Monetary policy since the crises

In the immediate aftermath of their crises, Thailand and Korea both followed tight monetary policies. Neither country allowed its monetary base to expand rapidly. Indeed, by the end of 1998 both countries had roughly the same amount of base money as they had at the onset of their crises.

The monetary authorities did extend enormous credit lines to their banking systems. From the onset of the crises to the end of 1997, Thai central bank credit to deposit money banks rose 761 percent. The corresponding figure for Korea was

281 percent. The period of "tight money" concluded by the end of 1998. In 1999 both countries significantly raised their money supplies, with the base rising more than 50 percent in Thailand and about 37 percent in Korea.

Based on this evidence we conclude that the Thai and Korean governments eventually moved to partially monetize their debt, but there was a substantial lag until they did so.

Real activity

The costs of the twin crises in terms of aggregate economic activity were very real, with both countries suffering large recessions.[10] In Thailand, the recession began in early 1997. By 1997:Q4 real GDP was 4.4 percent lower than it had been in 1996:Q4. The first half of 1998 saw real GDP fall a further 15 percent. In the following six months the economy grew at a fast pace, but by 1999:Q4 real GDP was still 5.8 percent below its level in 1996:Q4. In Korea, real GDP (seasonally adjusted) grew about 4 percent in the first three quarters of 1997, and then fell about 9 percent in the next three quarters through mid-1998. Since then growth has rebounded. Real GDP in 1999:Q4 was 7.1 percent above its level in 1997:Q3.

With this brief and selective review as background, we turn to our interpretation of the crises in Korea and Thailand.

Prospective deficits and currency crises: A benchmark model

In the introduction we argue that the Korean and Thai currency crises were caused by large prospective deficits associated with implicit bailout guarantees to failing banking systems. Here we formalize this argument using a simplified version of the model in Burnside, Eichenbaum, and Rebelo (1999). Our objectives are twofold. First, we explain the basic mechanisms at work in the more complicated model. Second, we show that the simple model can account for a key fact about the East Asian currency crises: They erupted after the banking crises began but before high deficits and excessive money growth were observed.

The key ingredients in the benchmark model are as follows. A small open economy with no barriers to trade is initially operating under a fixed exchange rate regime. Output is given exogenously and is constant.[11] At some point in time agents receive information that future deficits will be larger than they originally believed. Agents assume that the government will pay for the increase in the deficit entirely via seigniorage revenues. It is understood that the government will do this via a change in monetary policy that begins sometime in the future. Agents' demand for domestic real balances is decreasing in the domestic interest rate and increasing in real output. The government faces the usual intertemporal budget constraint. As is standard in the literature, we assume that the government follows a threshold rule according to which the fixed exchange rate regime is abandoned in the first period that net government debt reaches some exogenous upper bound. Thereafter, the economy operates under a floating exchange rate regime.

Turning to specifics, we assume that the model economy is populated by three sets of agents: domestic agents, a government, and foreigners. There is a single consumption good and no barriers to trade, so that purchasing power parity holds:

$$1) \quad P_t = S_t P_t^*.$$

Here, P_t and P_t^* denote the domestic and foreign price level respectively, while S_t denotes the exchange rate (units of domestic currency per unit of foreign currency). According to equation 1, the real cost of buying the good is the same in the domestic economy as abroad. For convenience, we assume that $P_t^* = 1$ so that foreign inflation is zero.

For simplicity, we assume that domestic agents' per period real income, Y, is constant over time. Private agents are competitive and can borrow and lend domestic currency at the nominal interest rate, R_t. The total demand for domestic money is given by:[12]

$$2) \quad \log\left(\frac{M_t}{P_t}\right) = \log(\theta) + \log(Y) - \eta R_t.$$

Here, M_t denotes the beginning of period t domestic money supply, and θ is a positive constant. According to equation 2, the demand for money depends positively on Y, and negatively on the opportunity cost of holding money: the nominal interest rate, R_t. The parameter η represents the semi-elasticity of money demand with respect to the interest rate.

In the absence of uncertainty, the nominal interest rate is equal to the real rate of interest, r_t, plus the rate of inflation, π_t:

$$3) \quad R_t = r_t + \pi_t.$$

By assumption, the home country is small relative to international capital markets so that r_t is exogenous from that country's perspective. So, absent capital market restrictions, r_t is the same as the risk-free real rate of interest in international capital markets. For the sake of simplicity, we assume that this rate is constant so that $r_t = r$ for all t.

The government of the home country purchases goods, g_t, makes transfer payments, v_t, levies lump sum taxes, τ_t, and can borrow at the real interest rate r. Again, for simplicity, we assume that g_t, v_t, and τ_t are constant over time and equal to g, v, and τ, respectively.

A sustainable fixed exchange rate regime

Suppose that the home country is initially in a fixed exchange rate regime so that $S_t = S$. Equation 1 implies that the domestic rate of inflation, π_t, is equal to the foreign rate of inflation, π_t^*, which we assume equals zero. It follows from equation 3 that the nominal rate of interest is equal to the constant real interest rate: $R_t = r$ for all $t \geq 0$. Under a fixed exchange rate, the domestic money supply is endogenous: It must equal the level of money demanded, given the exchange rate, S,

$$4) \quad M = S\theta Y \exp(-\eta r).$$

If the government tried to print more money than M, private agents would simply trade it, at the fixed exchange rate, for foreign reserves. Consequently, as long as the country is in a fixed exchange rate regime, the government cannot generate seigniorage revenues.[13]

Under what circumstances is the fixed exchange rate regime *sustainable*? In our model the answer to this question reduces to whether the money supply can be constant over time. Whether this is possible depends critically on whether the government can abstain from raising seigniorage revenues. This in turn depends on the government's fiscal policy.

To see the nature of the required restrictions on fiscal policy, note that with money constant for all t, the government's flow budget constraint is:

$$5) \quad \dot{b}_t = rb_t + g + v - \tau.$$

Here, b_t represents the government's stock of real debt, net of any assets, and $\dot{b}_t$ denotes the derivative of b_t with respect to time. According to equation 5, the change in b_t (more precisely, $\dot{b}_t$) is equal to the interest cost of servicing government debt, rb_t, plus the primary deficit, $g + v - \tau$. Imposing the condition that the present value of b_t goes to zero in the infinite future, we obtain the government's intertemporal budget constraint,[14]

$$6) \quad rb_0 = \tau - g - v.$$

According to equation 6, for the fixed exchange rate to be sustainable, the government surplus must be just large enough to cover the interest cost of servicing its initial debt. When this is the case, the government does not print money. It simply stands ready to trade domestic money for foreign money at the exchange rate S. Since the demand for money is constant, so too is the supply. So, as long as equation 6 holds, the economy will be in a sustainable fixed exchange rate equilibrium with $S_t = S$ for all t.

A currency crisis

To see how a banking crisis can generate a currency crisis, suppose that equation 6 initially holds. Then, at time $t = 0$, private agents learn that there has been an increase in the present value of the deficit equal to ϕ, say because of an increase in future transfer payments associated with bank bailouts. Also, suppose private agents correctly believe that the government will not undertake a fiscal reform to pay for the bank bailouts; that is, they will not raise taxes or lower real government purchases or transfers. While we could allow for a partial fiscal reform, for simplicity we assume that g, v, and τ remain constant at their initial pre-crisis values.[15] It follows that the *only* way that the government can satisfy its intertemporal budget constraint is to embark on a monetary policy that generates a present value of seigniorage revenues equal to ϕ:[16]

$$7) \quad \phi = PV(Seigniorage) = \int_{t^*}^{\infty} \frac{\dot{M}_t}{P_t} e^{-rt} dt + \sum_i \frac{\Delta M_i}{P_i} e^{-ri}.$$

Here, t^* denotes the time when the economy moves to a floating exchange rate regime, $\dot{M}_t$ is the derivative of the money supply with respect to time, and $\int_{t^*}^{\infty} \frac{\dot{M}_t}{P_t} e^{-rt} dt$ represents the present value of the resources that the government raises by printing money. The term $\sum_i \frac{\Delta M_i}{P_i} e^{-ri}$ represents changes in seigniorage revenue following discrete jumps in the money supply. These terms must be included because the money supply may jump discontinuously when the fixed exchange rate regime collapses or because of government monetary policy (see Burnside, Eichenbaum, and Rebelo, 1999 and 2000a).

Could the fixed exchange rate be sustained once new information about higher deficits arrives? Suppose, for a moment, that it could. Then the money supply would never change and the government could not collect any seigniorage revenues. So all the terms on the right-hand side of equation 7 would equal zero. But then the government's budget constraint would not hold. This contradicts the assumption that the fixed exchange rate regime is sustainable. We conclude that the government *must* at some point move to a

floating exchange rate system. The precise time at which this occurs depends on 1) the government's rule for abandoning fixed exchange rates, and 2) the government's new monetary policy.

With respect to 1, we follow a standard assumption in the literature that the government abandons the fixed exchange rate regime according to a threshold rule on government debt.[17] Specifically, we assume that the government floats the currency in the first time instance, t^*, when its net debt hits some finite upper bound. As it turns out, this is equivalent to abandoning the fixed exchange rate whenever the amount of domestic money sold by private agents in exchange for foreign reserves exceeds χ percent of the initial money supply (see the appendix). In addition to being a good description of what happens in actual crises, the threshold rule assumption can be interpreted as a short-run borrowing constraint on the government: It limits how much reserves the government can borrow to defend the fixed exchange rate.[18]

With respect to 2, we assume that at some point in the future, time T, the government will engineer a discrete increase in the money supply of γ percent relative to M, the level of the money supply during the fixed exchange rate regime. In addition it will set the growth rate of the money supply from then on equal to μ. The parameters μ and γ must be such that the government's intertemporal budget constraint, equation 7, holds. This specification decouples the endogenous timing of the speculative attack from the time at which the government undertakes its new monetary policy. Because of this we can allow for a delay between the end of the fixed exchange rate regime and when the government moves to monetize the debt.

Before turning to the quantitative properties of our model, we note that the rate of inflation, the money supply, and the level of government debt can be discontinuous in our perfect foresight economy. However, the exchange rate path must be continuous. To see why, suppose to the contrary that there was a discontinuous increase in the exchange rate at time t^*. Since purchasing power parity implies that $P_t = S_t$, inflation would be infinity at t^*. This would imply that the nominal interest rate would also be infinity at t^* so that money demand would be equal to zero. Private agents would want to sell all of the domestic money supply to the government. But the government is only willing to buy χ percent of it. Hence, this cannot be an equilibrium.

Equilibrium of the model: Numerical examples

In the appendix, we show how to solve for the equilibrium of the model economy. Here, we describe the characteristics of the equilibrium for a calibrated version of the model.

- We normalize real income, Y, and the initial exchange rate, S, to 1.
- We set the parameter ϕ to 0.25, a conservative estimate of the cost of Korea's banking crisis relative to its GDP.
- We set the semi-elasticity of money demand with respect to the interest rate, η, equal to 0.5. This is consistent with the range of estimates of money demand elasticities in developing countries provided by Easterly, Mauro, and Schmidt-Hebbel (1985). Since Korea is not included in that study, we discuss the sensitivity of our results to this parameter.
- We assume that the risk-free real interest rate, r, is equal to 1 percent and set the constant, θ, in money demand so that the model is consistent with the ratio of real balances to GDP in Korea before the crisis. See Burnside, Eichenbaum, and Rebelo (1999, 2000a). For $\eta = 0.05$, this implies a value of θ approximately equal to 0.06.
- Based on the evidence in Burnside, Eichenbaum, and Rebelo (1999), we set the threshold parameter, χ, to 0.03.
- For simplicity we normalize the government's initial stock of debt, b_0, to zero.
- The monetary base in Korea was roughly the same at the end of 1998 as at the beginning of the crisis. However, by the end of 1999, the base had risen by over 30 percent. Given these facts, the key question in deciding on a value for T is: When did agents become convinced that the government would have to bail the banks out? This is a difficult issue to resolve. Here we report results for $T = 3$. While our qualitative results are robust to this choice, we think further research on this question is important. At the end of this section we briefly consider one interesting implication of setting $T = 1$.
- We set the parameter γ to 0.1. Finally, we solve for the value of μ that satisfies the government's intertemporal budget constraint ($\mu = 0.043$).

Figure 3 displays the equilibrium path of the benchmark model. Two features are worth noting. First, the collapse of the fixed exchange rate regime takes place at time $t^* = 2.19$, *after* the new information about the deficit arrives ($t = 0$) but *before* the new monetary policy is implemented ($T = 3$). Second, inflation begins to rise at t^*, before the change in monetary policy. So, consistent with the classic results in

Sargent and Wallace (1981), future monetary policy affects current inflation. Because of purchasing power parity and the absence of nontradable goods, the rate of inflation is the same as the rate of depreciation of the exchange rate.

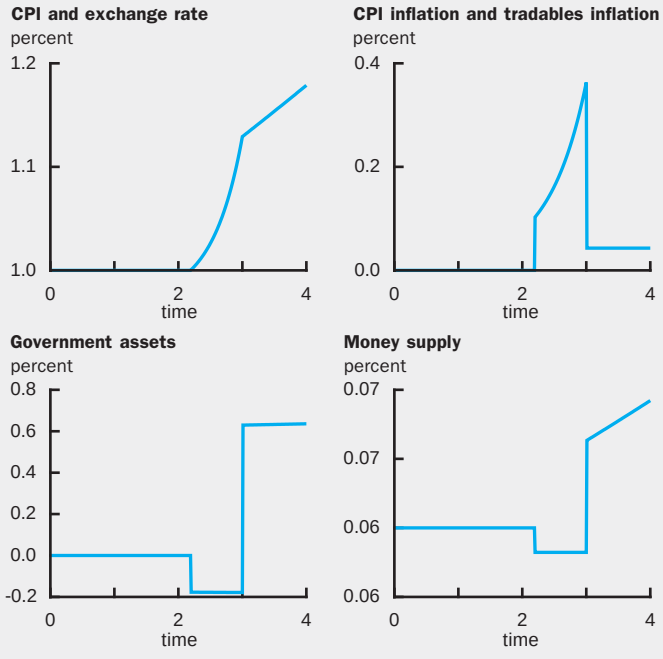
Next, consider the behavior of the money supply and net government assets ($-b_t$). As we argued earlier, the level of the money supply is constant as long as the fixed exchange rate regime lasts ($t < t^*$). It then drops by χ percent as agents trade domestic money for foreign reserves. Since the government's foreign reserves fall at t^*, the government's net assets fall by a corresponding amount. Thereafter, the money supply is constant until the government begins its new monetary policy. At time T there is a policy-induced jump in the money supply to M_T after which it grows at the constant rate μ. Since the government engineers increases in the money supply by retiring debt or purchasing foreign reserves, net government assets jump at time T and then increase at a rate that depends on the timing of the government bank bailouts.

Why doesn't the fixed exchange rate regime collapse at time 0?

The reader may wonder why the fixed exchange rate doesn't collapse at $t = 0$ when agents receive the new information about future deficits. To understand why the collapse generally occurs after $t = 0$, two things must be kept in mind. First, as long as the government has access to foreign reserves and is willing to use them, it can fix the price of its currency. It does so by exchanging domestic money for foreign reserves at the fixed price S. In our model the government is willing to do this until the level of domestic money falls by χ percent. Put differently, a fixed exchange rate regime is a price fixing scheme that will endure as long as the government has the ability and the willingness to exchange domestic currency for dollars. If the government was not willing to endure any increases in its debt, that is, it was not willing to buy back any of the domestic money supply at $S_t = S$, then the exchange rate regime would collapse at $t = 0$. Given the government's willingness to buy back no more than χ percent of the money supply, the key determinant of when the fixed exchange rate regime collapses is when money demand falls by χ. Second, as a result of the discrete increase in money supply at time T, inflation is monotonically increasing between t^* and T (see Burnside, Eichenbaum, and Rebelo, 2000a). This reflects the fact that in standard Cagan money demand models, the price level at time t is a function of discounted current and future money supplies. An important feature of this function is that the further out in time is the increase in the money supply, the less impact it has on the initial price level.[19] In general, inflation is too low at time zero to produce a fall in money demand large enough to trigger the government's threshold rule.[20]

FIGURE 3

Benchmark model



The preceding arguments suggest that the higher the interest rate elasticity of money, the sooner the fixed exchange rate collapses. Consistent with this intuition, we find that when $\eta = 1$, $t^* = 1.24$. When $\eta = 0.1$, t^* rises to 2.85. Notice that 1) even at the high value of η, the fixed exchange regime still collapses after $t = 0$, and 2) even at the low value of η, the fixed exchange rate regime still collapses before T.

Consistent with the previous intuition, the appendix shows that t^* satisfies:

$$8) \quad t^* = T + \eta \ln\left(\frac{\chi}{\chi + \gamma + \mu\eta}\right).$$

So, other things equal, the longer the government delays implementing its new monetary policy (the larger is T) and the more willing the government is to accumulate debt (the higher is χ), the later the

fixed exchange rate regime will collapse. In addition, the higher is the interest rate elasticity of money demand (the larger is η) and the more money the government prints in the future (the higher are γ and μ), the sooner the speculative attack will occur.[21]

Some caution is required in interpreting these results because we are not free to vary the parameters on the right-hand side of equation 8 independently of each other. For example, equation 8 indicates that t^* is increasing in the threshold rule parameter, χ, taking the parameters that control monetary policy (γ, μ, and T) as given. But these parameters must be adjusted whenever a different χ is considered because the government's intertemporal budget constraint must hold. This issue is addressed by Burnside, Eichenbaum, and Rebelo (1999), who show numerically that the qualitative conclusions emerging from equation 8 remain intact even after the appropriate adjustments are made. This is also the case for the simple model considered here. For example, if we set T to 1, then with one exception the equilibrium path of the model is qualitatively similar to the one depicted in figure 3. The exception is that t^* falls to 0.18 or a bit over two months. Interestingly, this is the time lag between when forward premia on baht–dollar exchange rates began to rise significantly and the Thai currency crises occurred (see Burnside, Eichenbaum, and Rebelo, 1999).

Strengths and weaknesses of the benchmark model

On the positive side, the benchmark model does what it was intended to do: It illustrates the fact that new information about prospective deficits can cause the collapse of a fixed exchange rate regime after information about the deficit arrives but before the government starts its new monetary policy. In addition, the model reproduces the fact that CPI inflation initially surges in the wake of the exchange rate collapse and then stabilizes at a lower level.[22]

On the negative side, 1) the model clearly overstates the actual rate of inflation in Korea after the crises, particularly in the period between t^* and T (see figure 2), and 2) the model does not account for the different response in tradable and nontradable goods prices. In assessing these shortcomings, it is important to note that the model's implications for inflation depend heavily on two simplifying assumptions. First, we assume that the only additional source of revenues available to the government in the aftermath of the currency crisis is seigniorage. Second, there is only one good in the model economy, and purchasing power parity holds. It follows from equation 1 that an x percent rate of devaluation is necessarily associated with an x percent rise in the price level. This is clearly counterfactual. In the next section, we discuss work in Burnside, Eichenbaum, and Rebelo (1999, 2000a) that examines the implications of relaxing these assumptions.[23]

Perturbations to the benchmark model

Allowing for nonindexed government liabilities

In the benchmark model, we assume that all of the government's liabilities are perfectly indexed, so that their real value is unaffected by a devaluation. In reality, governments have liabilities denominated in units of local currency that are not indexed to the rate of inflation. These liabilities are of two types: a) domestic bonds issued before information about a banking crisis becomes known, and b) obligations to programs like Social Security or commitments to purchase labor services and other nontraded goods whose value is preset in units of the domestic currency. Burnside, Eichenbaum, and Rebelo (1999, 2000a) discuss the impact of these types of liabilities on the implications of the benchmark model.

The basic point is that inflation reduces the real value of nonindexed liabilities and acts like a partial fiscal reform, effectively providing the government with a source of revenue other than seigniorage. But to gain access to these revenue sources, there must be inflation. In our model, inflation is possible only in a flexible exchange rate regime. So the presence of nonindexed liabilities does not allow the government to escape a currency crisis. However, it does allow the government to print less money than it would have to in the absence of nonindexed liabilities. This in turn implies that the modified model does a much better job of accounting for the observed post-crises rates of inflation in Korea and Thailand.[24]

Allowing for nontraded goods

The benchmark model assumes that all goods are tradable and that purchasing power parity holds. Because of this, it is inconsistent with two key facts about the crises in Korea and Thailand: 1) the rate of CPI inflation was much lower than the rate of depreciation in the won and the baht, and 2) the price of tradable goods rose much more than the price of nontradable goods after the fixed exchange rate regimes collapsed.

In modifying the benchmark model we are forced to confront the question What underlies the empirical failure of purchasing power parity? In its simplest form this condition asserts that the real cost of buying the CPI basket of goods is the same in all countries. In reality some goods simply aren't traded,

so there is no reason for their prices to be the same in different countries. Consequently, the real price of the CPI basket will not be equalized across countries. Purchasing power parity may also fail because transportation and distribution costs prevent tradable good prices from equalizing across countries.

Burstein, Neves, and Rebelo (2000) argue on empirical grounds that total distribution costs (including wholesale and retail services, marketing, and so on) are often more significant than the costs of transporting goods across countries. They study the role played by the distribution sector in shaping the behavior of real exchange rates during exchange rate based stabilizations. Burnside, Eichenbaum, and Rebelo (2000a) show how to use Burstein, Neves, and Rebelo's analysis to break the benchmark model's counterfactually tight link between the inflation rate and the rate of depreciation of the exchange rate. The key result is that once some stickiness in nontraded goods prices is allowed for, the modified model does a reasonable job of accounting quantitatively for the different post-crisis responses of traded and nontraded goods prices in Korea and Thailand.

The basic features of the modified model can be described as follows. As in Burstein, Neves, and Rebelo (2000), assume that it takes δ units of nontraded goods to distribute one unit of the traded good to the domestic retail sector. Let P_t^{NT} and P_t^T denote the time t price of a nontraded good and the time t price of a traded good before distribution. Suppose for simplicity that the distribution and retail sectors of the economy are perfectly competitive. Then the retail price of a traded good is equal to $P_t^T + \delta P_t^{NT}$. The CPI is defined to be the geometric average of the price of the nontraded good and the retail price of the traded good:

$$9)\quad P_t = \left(P_t^T + \delta P_t^{NT}\right)^{\omega}\left(P_t^{NT}\right)^{1-\omega},$$

where ω is a number between 0 and 1.

The demand for real balances is given by equation 2, where P_t is given by equation 9. By assumption, purchasing power parity holds for the price of traded goods, exclusive of distribution services. With P_t^* equal to 1, this implies $P_t^T = S$. Burnside, Eichenbaum, and Rebelo (2000a) also allow for nominal rigidities in the price of nontradable goods. With these changes, the modified model is qualitatively consistent with facts 1 and 2 above.

Much work remains to be done in assessing the empirical plausibility of the modified versions of the benchmark model discussed in this section. Still, the results in Burnside, Eichenbaum, and Rebelo (1999, 2000a) suggest that these types of models are capable of explaining the large departures from purchasing power parity and relatively low inflation rates observed in the wake of currency crises. Just as important, bringing the models into closer conformity with these aspects of the data does not alter our basic message: Unfunded prospective deficits can be an important source of currency crises.

Prospective deficits: Other countries

Throughout this article, we examine the role of unfunded prospective deficits as a potential cause of currency crises. We are not alone in this view. At the end of 1997, Standard and Poor's began to report estimates of contingent government liabilities stemming from implicit guarantees to financial sectors. Next, we discuss these estimates and their relationship to conventional debt measures.

Table 4 reproduces Standard and Poor's contingent government liability estimates as of January 2000. To arrive at these estimates, Standard and Poor's first estimates the lower and upper percentages of financial intermediaries' loans that are at risk under various scenarios it deems to be likely. These are reported in the column labeled "Group." These bounds are multiplied by a measure of the size of the financial system relative to GDP to generate estimates of lower and upper bounds for government contingent liabilities. These are reported in table 4 in the columns labeled "Lower bound" and "Upper bound." Note that these estimates can be large either because the financial system has substantial exposure to nonperforming loans or because a country's banking system is large relative to its GDP. The final column in table 4 summarizes the size of existing government debt relative to GDP.

Two features of table 4 are worth noting. First, there is enormous variation in the size of government liabilities across different countries. The performance of some countries on the low end like Denmark and Canada reflects very solid financial institutions, while the performance of countries like Bulgaria reflects the small size of their financial sector. At the high end, the performance of countries like Japan, Panama, Malaysia, China, the Czech Republic, Egypt, Korea, and Thailand reflects financial sectors that are both large and risky.

Second, there is *not* a tight link between existing government debt and contingent liabilities. For example, Belgium's government has a very high debt to GDP ratio of 111 percent, but low contingent liabilities

TABLE 4

Standard and Poor's contingent liability estimates, January 2000, percent of GDP

Group	Country	Lower bound	Upper bound	Government debt
5% – 15%	Australia	4	13	31
	Belgium	4	12	111
	Canada	4	13	86
	Denmark	3	8	56
	France	4	12	61
	Germany	6	17	61
	Luxembourg	5	16	4
	Netherlands	10	29	67
	Sweden	2	7	68
	Switzerland	9	26	54
	United Kingdom	6	19	47
	United States	7	21	57
10% – 20%	Austria	9	18	63
	Chile	6	13	30
	Finland	5	10	45
	Hong Kong	16	32	12
	Ireland	11	21	52
	Italy	6	12	66
	New Zealand	11	22	36
	Norway	8	16	31
	Portugal	11	22	57
	Singapore	12	24	86
	South Africa	8	16	50
	Spain	10	21	64
	Taiwan	16	32	36
15% – 30%	Argentina	3	7	49
	Columbia	6	12	36
	Estonia	4	8	13
	Hungary	3	6	59
	Israel	13	25	110
	Japan	29	59	133
	Panama	17	33	76
	Philippines	8	15	67
	Poland	4	8	42
	Slovenia	5	10	33
	Uruguay	6	12	36
25% – 40%	Bolivia	15	25	90
	Brazil	9	14	68
	Croatia	10	16	29
	Cyprus	26	42	60
	Greece	8	13	104
	Korea	45	72	66
	Kuwait	17	28	57
	Lebanon	20	33	123
	Malaysia	37	59	37
	Morocco	12	19	98
	Oman	11	17	32
	Peru	6	10	32
	Saudi Arabia	16	25	NA
	United Arab Emirates	15	24	NA
35% – 70%	Bulgaria	0	3	82
	China	40	79	17
	Czech Rep.	23	45	17
	Egypt	25	50	106
	India	8	16	70
	Indonesia	9	19	101
	Kazakhstan	3	6	21
	Latvia	5	10	16
	Lithuania	5	10	19
	Mexico	6	13	48
	Pakistan	7	14	83
	Romania	6	12	30
	Russia	4	8	145
	Slovakia	20	41	36
	Thailand	51	101	31
	Tunisia	23	45	79
	Turkey	8	16	55
	Venezuela	4	8	29

Note: NA indicates not available.

(the upper bound is 12 percent of GDP). In contrast, Malaysia's government has a moderate debt to GDP ratio of 37 percent but high contingent liabilities (the upper bound is roughly 60 percent of GDP). Some countries, like Japan, have both a high debt to GDP ratio (roughly 130 percent) and large contingent liabilities (the upper bound is approximately 60 percent of GDP).

We conclude by emphasizing, as does Standard and Poor's, that the estimates reported in table 4 embed a host of assumptions and must be interpreted with caution. Still, there is clearly enormous variation in the exposure of different governments to future contingent liabilities, and that exposure is not well estimated by conventional debt measures.

Conclusion

This article reviews and interprets the recent currency crises in Korea and Thailand. We argue that a prime cause of the crises were large, implicit government guarantees to financial sectors. To articulate this view, we present and analyze versions of the model in Burnside, Eichenbaum, and Rebelo (1999). While successful on a number of dimensions, the model clearly leaves out various factors that were important parts of the story. For example, we assume that agents discovered at a particular point that the banks were failing and that the government was going to bail them out. The truth is obviously more complicated. Market participants—like generals—must operate in the fog of battle. Without a doubt, the fog was thick in Korea and Thailand. The process by which agents cut through the fog and converged on their views about banks' future prospects influenced the exact timing of the crises. Modeling that process would almost surely overturn the stark implication of our benchmark model that the timing of the currency crises was perfectly predictable.[25] However, it would not overturn the basic message: Large unfunded prospective deficits can be a prime source of currency crises.

APPENDIX

Solving for the equilibrium of the benchmark model

Here, we show how to solve for the equilibrium path of the benchmark model and determine the time of the speculative attack. Recall that the demand for domestic money is given by:

$$\text{A1)}\quad \log(M_t) = \log(\theta) + \log(Y) + \ln(P_t) - \eta R_t.$$

Using the fact that $R_t = r + \pi_t = r + \frac{\dot{P}_t}{P_t}$, and solving for $\ln(P_t)$, we obtain

$$\text{A2)}\quad \ln P_t = \eta r - \log(\theta) - \log(Y) + \frac{1}{\eta}\int_t^{\infty} e^{-(i-t)/\eta} \ln M_i di.$$

Equation A1 implies that for all $t \leq t^*$,

$$\text{A3)}\quad \log(S) = \log(M) - \log(Y) - \log(\theta) + \eta r.$$

At the time of the speculative attack, t^*, $\ln S_{t^*} = \log S$, so that equation A1 implies,

$$\text{A4)}\quad \ln S_{t^*} = \log(M) - \log(Y) - \log(\theta) + \eta r.$$

However, purchasing power parity and equation A2 imply that

$$\text{A5)}\quad \ln S_{t^*} = \eta r - \log(Y) - \log(\theta) + \frac{1}{\eta}\int_{t^*}^{\infty} e^{-(i-t)/\eta} \ln M_i di.$$

Equations A4 and A5 and continuity of the price level and S_t imply

$$\text{A6)}\quad \log(M) = \frac{1}{\eta}\int_{t^*}^{\infty} e^{-(i-t^*)/\eta} \ln M_i di.$$

The government's flow budget constraint is given by:

$$\text{A7)}\quad \Delta b_t = -\Delta m_t \quad \text{if } t \in I$$
$$\dot{b}_t = r b_t + g + v - \tau - \dot{m}_t - \pi_t m_t \quad \text{if } t \notin I,$$

where $\dot{m}_t + \pi_t m_t = \dot{M}_t / P_t$ represents seigniorage revenues. As in Drazen and Helpman (1987), the household's budget constraint (equation A7) takes into account the possibility of discrete changes in M_t and b_t at a finite set of points in time, I. These discrete jumps occur at the point in time when the exchange rate regime collapses, t^*, and the point in time T, when the government begins to implement its new monetary policy.

The flow budget constraint, together with the condition $\lim_{t\to\infty} e^{-rt} b_t = 0$, implies the following intertemporal budget constraint for the government:

$$\text{A8)}\quad b_0 = \int_0^{\infty} e^{-rt}(\tau - g - v + \dot{m}_t + \pi_t m_t)\, dt + \sum_{i \in I} e^{-ri}\Delta m_i.$$

According to this condition, the present value of future surpluses, including the value of seigniorage revenues, must equal the value of the government's net initial debt. Given our assumption that government purchases, taxes, and transfers are constant for all t, after receiving the news about the deficit, the government budget constraint implies:

$$\text{A9)}\quad \phi = \int_0^{\infty} (\dot{m}_t + \pi_t m_t) e^{-rt} dt + \sum_i \Delta m_i e^{-ri}.$$

Recall that we assume that the government adopts a threshold rule for when it abandons the fixed exchange rate regime. One way to formulate this rule is as in Burnside, Eichenbaum, and Rebelo (1999): The government abandons the fixed exchange rate when net debt is equal to Ψ percent of GDP. Since we assume that $Y = 1$ and b_0 is equal to zero, at t^*, b_{t^*} satisfies

$$b_{t^*} = \Psi = \frac{(M - M^*)}{S}.$$

It follows that we can reparameterize the threshold rule as one in which the government abandons the fixed exchange rate when the money supply falls by χ percent. From the previous expression, it follows that the money supply at time t^* satisfies

$$\text{A10)}\quad M^* = M e^{-\chi},$$

where $e^{-\chi}$ is equal to $(1 - \Psi\, S/M)$.

At time T the government increases the money supply by γ percent instantaneously and then lets the money supply grow at the rate μ. Consequently,

$$\text{A11)}\quad M_t = M e^{\gamma + \mu(t-T)},\ t \geq T.$$

Equations A10 and A11 imply that we can write equation A6 as,

$$\text{A12)}\ \log(M) = \frac{1}{\eta}\int_{t^*}^{T} e^{-(i-t^*)/\eta}\ln(Me^{-\chi})di + \frac{1}{\eta}\int_{T}^{\infty} e^{-(i-t^*)/\eta}(\ln M + \gamma + \mu(i-T))di.$$

Evaluating the different integrals and solving for t^* we obtain:

$$\text{A13)}\quad t^* = T + \eta\log\frac{\chi}{\chi+\gamma+\mu\eta}$$

$$\phi = \int_0^{\infty}(\dot{m}_t + \pi_t m_t)e^{-rt}dt + \Delta M_{t^*}e^{-rt^*} + \Delta M_T e^{-rT}.$$

Using the fact that 1) between t^* and T, $\dot{m}_t + \pi_t m_t = 0$, 2) $R_t = r + \pi_t = r + \mu$ for all $t \geq$ T, and 3) $m_t = \theta Y e^{-\eta R_t}$, along with equations A10 and A11, we can rewrite the government budget constraint (equation A9) as:

$$\text{A14)}\ \phi = \int_T^{\infty}\theta\mu Y e^{-\eta(r+\mu)}e^{-rt}dt + \left(\frac{Me^{-\chi}-M}{S}\right)e^{-rt^*} + \left(\frac{Me^{\gamma}-Me^{-\chi}}{P_T}\right)e^{-rT}$$

$$= \theta\frac{\mu Y}{r}e^{-\eta(r+\mu)}e^{-rT} + \left(\frac{Me^{-\chi}-M}{S}\right)e^{-rt^*} + \left(\frac{Me^{\gamma}-Me^{-\chi}}{P_T}\right)e^{-rT}.$$

In order to proceed, we must solve for P_T. Equations A2 and A11 imply that

$$\text{A15)}\ \ln P_t = \eta r - \log(Y) - \log(\theta) + \frac{1}{\eta}\int_t^{\infty} e^{-(i-t)/\eta}\left[\log(M) + \gamma + \mu(i-T)\right]di$$

for all $t \geq T$, or

$$\text{A16)}\ \ln(P_t) = \eta r - \log(Y) - \log(\theta) + \mu(t+\eta) + \log(M) + \gamma - \mu T.$$

It follows that

$$\text{A17)}\ P_T = \frac{M}{\theta Y}e^{\eta(r+\mu)+\gamma}.$$

Substituting equations A3, A13, and A17 into A14, we obtain

$$\text{A18)}\ \phi/\theta = \frac{\mu Y}{r}e^{-\eta(r+\mu)}e^{-rT} + Ye^{-\eta r}(e^{-\chi}-1)e^{-rt^*} + Ye^{-\eta(r+\mu)-\gamma}(e^{\gamma}-e^{-\chi})e^{-rT},$$

where t^* is given by equation A13. Note that given values of ϕ, θ, η, r, χ,γ, and T, equation A18 is one equation in one unknown: μ.

Finally, for $t^* < t < T$, P_t can be computed as follows:

$$\begin{aligned}\ln P_t &= \eta r - \log(\theta) - \log(Y) + \frac{1}{\eta}\int_t^T e^{-(i-t)/\eta}\log M_i di + \frac{1}{\eta}\int_T^{\infty} e^{-(i-t)/\eta}\log M_i di \\ &= \eta r - \log(\theta) - \log(Y) + \log M + e^{(t-T)/\eta}(\mu\eta+\gamma) - \left[1-e^{(t-T)/\eta}\right]\chi.\end{aligned}$$

It follows that

$$\frac{d\ln P_t}{dt} = \frac{1}{\eta}e^{(t-T)/\eta}(\mu\eta+\gamma) + \frac{\chi}{\eta}e^{(t-T)/\eta}.$$

NOTES

[1]See Kaminsky and Reinhardt (1999) for an empirical analysis of twin crises.

[2]We refer the reader to Burnside, Eichenbaum, and Rebelo (2000a) for a detailed analysis of the modified model.

[3]Given space constraints, we refer the reader to the papers cited in table 2 for the methodology used to generate these estimates. Basically, the numbers reflect authors' estimates of the aggregate net worth of protected insolvent institutions.

[4]Values of the Thai and Korean currencies were obtained from the IMF International Financial Statistics.

[5]Notice also that there is an overshooting pattern apparent in the exchange rate data, in the sense that each currency appreciated from its value in January 1998 until the end of our sample period, March 2000. Taking this into account, by March 2000, the baht and won had depreciated by roughly 32 percent and 18 percent of their respective pre-crisis values. In this article, we do not formally address possible causes of the overshooting pattern. Burnside, Eichenbaum, and Rebelo (2000a) argue that a version of the benchmark model in which output first declines and then recovers after the crises can qualitatively account for the observed overshooting pattern of exchange rates.

[6]If banks have open exposure to foreign currency risk, a currency devaluation will lead to a decline in the real value of banks' assets, reduce their net worth, and result in an increase in bank failures. Burnside, Eichenbaum, and Rebelo (2000b) discuss how government guarantees to banks' foreign creditors led banks to not hedge the currency mismatch in their assets and liabilities, leaving them exposed to precisely this kind of currency risk.

[7]All stock market data were obtained from Bloomberg. The mnemonics for Thailand are SETBANK, SETFIN, and SETCOMM, respectively. For Korea the mnemonics are KOSPBANK, KOSPFIN, and KOSPMAN. These indexes reflect values in local currencies.

[8]Statistics on prices in Thailand were obtained from the "Data bank" at the Bank of Thailand website, www.bot.or.th/. Korean price data were obtained from the "Statistics" section of the Bank of Korea's website, www.bok.or.kr/ and from Datastream.

[9]The data on which this discussion is based are taken from the following sources. Statistics on fiscal indicators for Thailand were obtained from the Central Bank of Thailand website "Data bank" and from IMF (2000b). For Korea, the data were taken from IMF (2000a).

[10]Statistics on GDP in Thailand were obtained from the Bank of Thailand "Data bank" website. Korean GDP data were obtained from the Bank of Korea's "Statistics" website.

[11]This last assumption is clearly counterfactual. Burnside, Eichenbaum, and Rebelo (2000a) modify the model to allow for a decline in output after a currency crisis, followed by a recovery. The basic message about the link between prospective deficits and currency crises remains unaffected by this modification.

[12]Specifications of money demand like equation 2 are often referred to as "Cagan money demand functions."

[13]If there were growth in either the foreign price level or domestic real income, the government would collect some seigniorage revenue in a fixed exchange rate regime. However, this would not affect our basic argument. The present value of such seigniorage revenues would be pledged to help cover the present value of the deficit that was anticipated in the initial fixed exchange rate regime.

[14]Technically, this requirement is given by the condition $\lim_{t\to\infty} e^{-\pi t} b_t = 0$.

[15]Our basic result would not be affected by a fiscal reform as long as the present value of the change in the primary surplus induced by the reform was less than ϕ.

[16]This result is formally proved in the appendix.

[17]See, for example, Krugman (1979), Flood and Garber (1984), and Lahiri and Végh (1999).

[18]Drazen and Helpman (1987), as well as others, have proposed a different rule for the government's behavior: Fix future monetary policy and allow the central bank to borrow as much as possible provided the present value budget constraint of the government is not violated. This rule ends up being equivalent to a threshold rule. See Burnside, Eichenbaum, and Rebelo (1999).

[19]In our model, the price level at time t is given by:

$$\ln(P_t) = \eta r - \ln(\theta) - \ln(Y) + \eta^{-1} \int_t^{\infty} e^{-(i-t)/\eta} \ln(M_i) di.$$

[20]To see why the speculative attack must occur before time T, suppose to the contrary that the attack actually occurred at time T. Since the government raises the money supply discretely at time T, inflation and the nominal interest rate would be infinity at T. But then money demand would be zero and the money market could not clear.

[21]It can be shown that whenever equation 8 implies a negative value for t^*, the exchange rate regime collapses at $t = 0$. This will happen for: 1) sufficiently high interest elasticities of money demand; 2) low values of χ, or 3) large values of γ and μ required to finance the prospective deficit. In this case the exchange rate will jump at time zero. This does not contradict our argument that the exchange rate path must be continuous. This is because the discontinuity in the exchange rate at time zero coincides with the arrival of the unanticipated news about prospective deficits.

[22]For example, in the model, the inflation rate during the year from October 1997 to October 1998 is 11.25 percent. The inflation rate in the year after is roughly 4 percent. The corresponding rates of CPI inflation in the Korean data are roughly 7 percent and 1 percent, respectively.

[23]Burnside, Eichenbaum, and Rebelo (2000a) also discuss the implications of relaxing the assumption that output is constant after the speculative attack.

[24]For example, steady-state inflation in the modified model drops by a factor of three relative to its value in the benchmark model.

[25]Burnside, Eichenbaum, and Rebelo (2000c) analyze a model in which government guarantees to banks' foreign creditors imply that a currency crisis will almost surely occur. But the time at which it occurs is stochastic.

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