

CURRENCY CRISES AND MACROECONOMIC PERFORMANCE

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Abstract

This paper presents some theory and evidence on the implications of sudden currency depreciations for output and inflation. It identifies some of the characteristics shared by countries which have suffered falling output in the aftermath of a currency crisis, and it presents a small model which rationalises aspects of this common experience. The model is then used to derive the optimal monetary policy response to a crisis. A key result is that a currency crisis which coincides with a banking crisis is more likely to depress output and may call for an accommodating monetary policy.

JEL Classification Numbers: E4; E5; F3

Keywords: currency crises; monetary policy

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1. Introduction

Over the past decade or so, events in east Asia, eastern Europe and Latin America have invigorated research into sudden currency depreciations. Much of the recent interest in depreciations has collected around their proximate causes and their short-term policy implications. By contrast, the longer-term effects of sudden depreciations have been a relatively minor theme in the literature. This paper addresses these longer-term effects. It presents evidence on the effects of currency crises in a substantial number of cases over a 34-year period ending in 1998, and it offers a simple theoretical framework for exploring the dynamic response of an economy to a sudden depreciation of its currency.

The data show that sudden nominal depreciations occasionally stimulate an economy, but more frequently they lead to falls in output. The adverse effects of a currency crisis on output turn out to be most pronounced in countries which simultaneously have banking crises; which have a greater trade dependency; whose exchange rates are naturally volatile; and in countries which are poor.

The data also identify some of the effects of currency crises on inflation. Firm prior expectations of price behaviour are difficult to form. On the one hand, sudden depreciations add directly to the cost of imports. But this effect could be at least partially, and perhaps more than fully, offset when the depreciation coincides with falling aggregate demand.

For the countries and crises in our sample, the offset turns out to be partial. The average inflation rate of most countries is higher in the two years after a crisis than it was in the two years preceding. But the increase is not always very great, and in a fair proportion of cases – about 30 per cent – average inflation actually fell after a crisis.

The formal theoretical exercise in the paper rationalises some of these features of sudden depreciations, describing the propagation process with a simple monetary model, and identifying some of the factors which distinguish benign from malign depreciations. The condition of the banking system and the exposure of the economy to imported inflation are highlighted in the analysis.

The model is then used to devise monetary policy rules for crises. It shows that a monetary authority which seeks price and output stability is most likely to tighten policy in response to a currency crisis when the crisis has not disrupted the domestic financial system. In the event of twin banking and currency crises, the monetary authority might have to ease policy, unless there is substantial import price inflation. The optimal policy is subject to developments in the banking system because a twin crisis will tend to produce a much larger rise in the domestic interest rate than would a simple increase in the world interest rate. In these circumstances, the dampening effects of the higher interest rates on activity can overwhelm the stimulus from a depreciated exchange rate.

The next section of the paper presents data on some of the currency crises that have occurred around the world over a 34-year period. Section 3 presents the formal modelling and Section 4 concludes with a brief summary of the main results.

2. Some Characteristics of Currency Crises

In this section we present some statistics describing the behaviour of output and inflation in the aftermath of a currency crisis. Similar exercises have been undertaken by, *inter alia*, Bordo and Eichengreen (1999), Hutchison and McDill (1998), and the IMF (1998). The approach in this paper differs from past studies mainly in that it has a greater scope, and that it calculates conditional probabilities of the output and inflation response to a crisis.

We consider a sample of 35 developed and developing countries between 1965 and 1998.¹ Following Kraay (2000), we define a currency crisis as a (nominal)

¹ Our sample is that used by Kraay (2000), although a number of crises have been eliminated because of a lack of macroeconomic data needed for our analysis. The countries and timing of each crisis are listed in Appendix A.

depreciation of the domestic currency against the US dollar of at least 10 per cent in one month. We then eliminate any of these depreciations which were not preceded by a period of exchange rate stability, defined as an average absolute monthly change of less than 2.5 per cent over the past year. This ensures that the currency crises identified are sudden, sharp depreciations. Finally, in order to avoid the double-counting of single prolonged crises, we eliminate any currency crisis which follows a currency crisis within one year. These criteria result in a sample of 78 currency crises.

For each country we construct a time series of the output gap, calculated as the log of real GDP less a Hodrick-Prescott filter estimate of trend.² The task then is to identify whether each currency crisis had an effect on output. There are a number of ways that this might be done. Our approach, which has the advantage of being simple, systematic and transparent, is to add a dummy variable representing the currency crisis to an autoregressive model of the output gap. If the coefficient on the dummy variable is statistically significant (at the 10 per cent level), then we conclude that the currency crisis had an effect on output. In order to allow for the possibility of some lagged effect of the currency crisis on output, the precise forms of the regressions estimated are:

$$G_t = \alpha + \sum_{i=1}^k \beta_i G_{t-i} + \sum_{i=0}^4 \tau_i D_{t-i} + v_t \quad (1)$$

for countries with quarterly GDP data and:

$$G_t = \alpha + \sum_{i=1}^k \beta_i G_{t-i} + \sum_{i=0}^1 \tau_i D_{t-i} + v_t \quad (2)$$

for countries with annual GDP data. G represents the output gap and D the dummy variable for the currency crisis. The length of the autoregressive process in each regression is chosen according to the Akaike criterion. The lag lengths on the dummy variable of 4 for the quarterly data regressions and 1 for the annual data

² Following convention, we set the smoothing parameter in the filter equal to 100 (1 600) for countries with annual (quarterly) GDP data.

regressions are chosen to allow up to a year for the currency crisis to have an effect.

The result of this approach for our sample of countries and currency crises is shown in Table 1. Of the 78 currency crises, 23 (or 29 per cent), are estimated to have had a significant negative effect on output, 5 per cent a positive effect, and 65 per cent no discernible effect.³ Confidence intervals at 95 per cent for these statistics are also reported. These data suggest that despite boosting external competitiveness, sudden depreciations are more likely to have a negative, rather than positive, effect on output growth.⁴

Table 1: All Currency Crises

Effect on output

	Number	Probability
Output gap		
Negative	23	0.29
Positive	4	0.05
No effect	51	0.65
Total	78	
95 per cent confidence interval		
Negative		0.19–0.40
Positive		0.00–0.10
No effect		0.55–0.76

³ We tested the sensitivity of these results to our definition of a currency crisis by changing the ‘10 per cent in one month’ rule to ‘20 per cent in three months’. This did not materially alter the results.

⁴ Although currency crises are defined in terms of *nominal* depreciations, the short (one month) time frame and the presumed stickiness of inflation mean that, in almost all cases, the *real* exchange rate will also depreciate.

These conclusions can be refined by considering various partitions of the data. For example, Table 2 shows the sub-sample of currency crises which coincided with banking crises.⁵ Of these ‘twin crises’, 47 per cent were associated with a fall in output growth (although the sample size is small and the 95 per cent confidence interval extends from 25 per cent to 70 per cent), and there are no positive outcomes. Table 3 divides the sample into higher-income and lower-income countries, based on median per capita income in 1982 (which is the midpoint of our sample’s time period). Only 25 per cent of currency crises in higher-income countries had a negative effect on output, compared with 33 per cent for lower-income countries.⁶ Since there are as many high-income as low-income countries, but a greater number of crises in low-income countries, poor countries also appear more likely to suffer a crisis.

Table 2: Currency Crises with Banking Crises

Effect on output

	Number	Probability
Output gap		
Negative	9	0.47
Positive	0	0.00
No effect	10	0.53
Total	19	
95 per cent confidence interval		
Negative		0.25–0.70
Positive		na
No effect		0.30–0.75

⁵ The list and dates of banking crises have been compiled from Caprio and Klingebiel (1996), Demirgüç-Kunt and Detragiache (1997) and Kaminsky and Reinhart (1996). Further details are provided in Appendix A.

⁶ Mean per capita income in our sample of countries is substantially higher than median, reflecting the inclusion of a few very rich countries. If mean per capita income is used to divide the sample, 14 per cent of currency crises in higher-income countries and 36 per cent in lower-income countries had a negative effect on output, reinforcing the results in Table 3.

Table 3: Currency Crises by Income

Effect on output		
	Number	Probability
<i>Higher-income countries</i>		
Output gap		
Negative	8.5	0.25
Positive	2.0	0.06
No effect	24.0	0.70
Total	34.5	
95 per cent confidence interval		
Negative		0.10–0.39
Positive		0.00–0.14
No effect		0.54–0.85
<i>Lower-income countries</i>		
Output gap		
Negative	14.5	0.33
Positive	2.0	0.05
No effect	27.0	0.62
Total	43.5	
95 per cent confidence interval		
Negative		0.19–0.47
Positive		0.00–0.11
No effect		0.48–0.76

The sample is also divided into relatively open and closed countries (based on the ratio of exports plus imports to GDP in 1982) in Table 4. Unsurprisingly, currency crises are more likely to have no effect in relatively closed economies (73 per cent) than in open economies (59 per cent). Finally, in Table 5, we split the sample into countries with high and low exchange-rate volatility using the standard deviations of the monthly changes in the value of their currencies. Those countries whose currencies have lower than average volatility are less likely to be adversely affected by a currency crisis (20 per cent) than countries whose exchange rates are traditionally more volatile (37 per cent).

Table 4: Currency Crises by Openness

Effect on output

	Number	Probability
<i>Higher-trade countries</i>		
Output gap		
Negative	13.5	0.33
Positive	3.5	0.09
No effect	24.0	0.59
Total	41.0	
95 per cent confidence interval		
Negative		0.19–0.47
Positive		0.00–0.17
No effect		0.43–0.74
<i>Lower-trade countries</i>		
Output gap		
Negative	9.5	0.26
Positive	0.5	0.01
No effect	27.0	0.73
Total	37.0	
95 per cent confidence interval		
Negative		0.12–0.40
Positive		0.00–0.05
No effect		0.59–0.87

Table 5: Currency Crises by Exchange Rate Variability
Effect on output

	Number	Probability
<i>Higher-volatility countries</i>		
Output gap		
Negative	16	0.37
Positive	1	0.02
No effect	26	0.60
Total	43	
95 per cent confidence interval		
Negative		0.23–0.52
Positive		0.00–0.07
No effect		0.46–0.75
<i>Lower-volatility countries</i>		
Output gap		
Negative	7	0.20
Positive	3	0.09
No effect	25	0.71
Total	35	
95 per cent confidence interval		
Negative		0.07–0.33
Positive		0.00–0.18
No effect		0.56–0.86

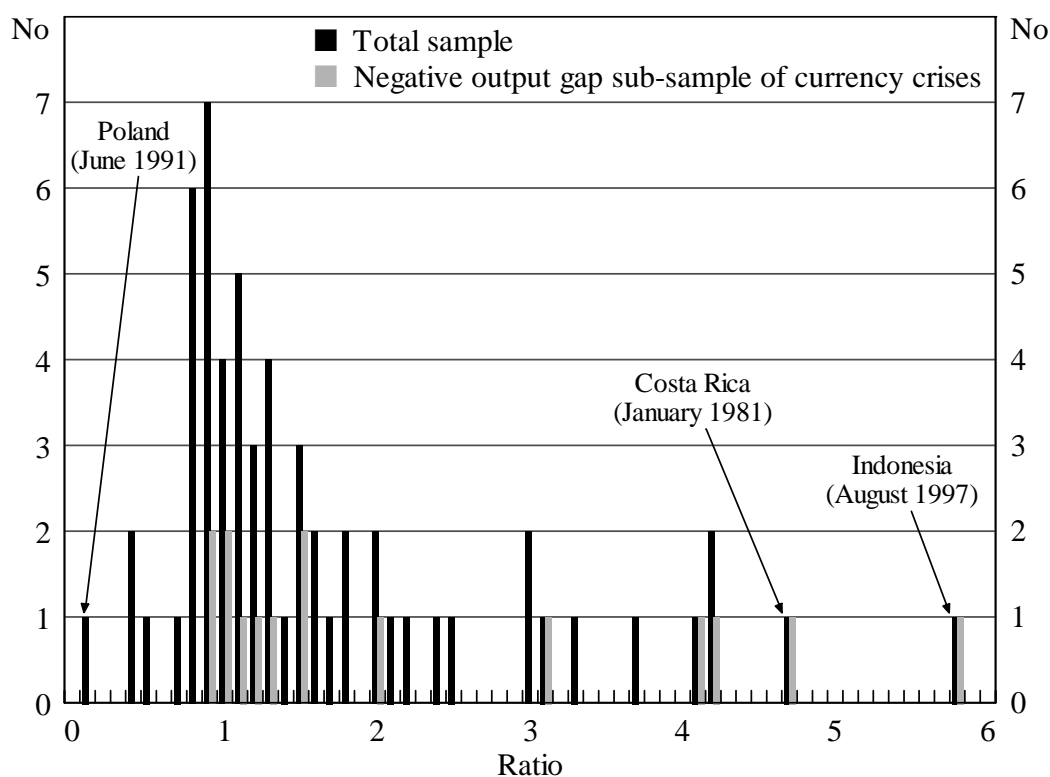
The finding that currency crises tend to have a negative effect on output in the short run is common in the literature (e.g. Bordo and Eichengreen (1999); Hutchison and McDill (1998); IMF (1998)), and may be explained in terms of income and substitution effects. The income effect of a sudden depreciation, such as the increase in interest payable on foreign-currency denominated debt, is immediate, whereas the substitution towards domestic goods in response to the lower exchange rate may happen with a lag. Unsurprisingly, a country hit by a banking crisis as well as a currency crisis is more likely to suffer a contraction in output. It is also uncontroversial that exchange rate movements are more likely to affect aggregate output in open economies than closed economies.

The finding that higher-income countries tend to be less adversely affected by currency crises was also expected, for a number of reasons. To begin with, higher-income countries tend to have more robust financial and banking systems, which are better able to handle shocks. Also, as discussed in Hausmann, Panizza and Stein (2000), higher-income countries are more likely to be able to borrow abroad in their own currency, suggesting a lower reliance on foreign-currency-denominated foreign debt. And finally, lower-income countries tend to have higher exchange-rate volatility: 14 of the 17 poorest countries in the sample have high exchange-rate volatility on our criteria.

Turning now to the behaviour of inflation in the aftermath of a currency crisis, Figure 1 depicts the changes in inflation that take place after currency crises. The horizontal axis measures average year-ended CPI inflation in the two years after a currency crisis to the same average in the two years preceding the crisis. So, for example, a ratio of two means that average inflation doubled from the two years before a crisis to the two years after it. The lack of CPI data for some countries and time periods has reduced the sample size from 78 to 59.

The distribution is clearly positively skewed. The finding that inflation tends to rise following a currency crisis is not surprising, although it is of some interest that in about 30 per cent of crises, average inflation actually fell. Interestingly, these falls were not confined to countries which experienced output contractions. In fact, average inflation fell in only 2 of the 15 crises in which the output effect was negative. Therefore, at least in our sample, when a currency crisis has an adverse effect, both output and inflation tend to deteriorate.

Figure 1: Inflation Changes
Number of countries



Notes: The figure shows average inflation in the two years following a crisis, divided by average inflation in the two years preceding the crisis. Figures greater than one indicate a rise in inflation.

Table 6 divides the sample according to income, Table 7 according to openness, and Table 8 according to exchange rate variability. Inflation is much more likely to rise substantially in lower-income countries after a currency crisis than in higher-income countries, and in relatively open economies than closed economies. The results of the stable/variable exchange-rate country split are striking. Average inflation in countries accustomed to exchange rate stability rose by at least 50 per cent in only one quarter of all currency crises. The corresponding figure for countries more accustomed to exchange rate variability is about 56 per cent. Once again, this may be reflecting a correlation between income and exchange rate variability.

Table 6: Currency Crises by Income
Post-crisis inflation relative to pre-crisis inflation

Inflation ratio	Number	Proportion
Higher-income countries		
<0.5	2.0	0.07
0.5–0.9	8.0	0.29
1.0–1.4	9.5	0.35
1.5–2.0	5.0	0.18
>2.0	3.0	0.11
Total	27.5	
Lower-income countries		
<0.5	1.0	0.03
0.5–0.9	7.0	0.22
1.0–1.4	7.5	0.24
1.5–2.0	5.0	0.16
>2.0	11.0	0.35
Total	31.5	

Table 7: Currency Crises by Openness
Post-crisis inflation relative to pre-crisis inflation

Inflation ratio	Number	Proportion
Higher-trade countries		
<0.5	2.0	0.06
0.5–0.9	8.0	0.22
1.0–1.4	8.5	0.24
1.5–2.0	8.0	0.22
>2.0	9.5	0.26
Total	36.0	
Lower-trade countries		
<0.5	1.0	0.04
0.5–0.9	7.0	0.30
1.0–1.4	8.5	0.37
1.5–2.0	2.0	0.09
>2.0	4.5	0.20
Total	23.0	

Table 8: Currency Crises by Exchange Rate Variability
 Post-crisis inflation relative to pre-crisis inflation

Inflation ratio	Number	Proportion
Higher-volatility countries		
<0.5	1	0.04
0.5–0.9	5	0.19
1.0–1.4	6	0.22
1.5–2.0	7	0.26
>2.0	8	0.30
Total	27	
Lower-volatility countries		
<0.5	2	0.06
0.5–0.9	12	0.38
1.0–1.4	10	0.31
1.5–2.0	3	0.09
>2.0	5	0.16
Total	32	

Two final hypotheses deserve comment. First, it might be thought that the predisposition of lower-income countries to suffer more from currency crises and the correlation between income and exchange rate stability may reflect the tendency of exchange rates in poor countries to depreciate by more in a crisis. Table 9 dispels this idea. It shows the distribution of the 1-month depreciations for our sample of currency crises and reveals no significant difference between higher-income and lower-income countries. Just under two-thirds of currency crises for both groups involved depreciations of 20 per cent or less, although depreciations in lower-income countries were a little more likely to be in the 16–20 per cent band. Depreciations of more than 20 per cent in higher-income and lower-income countries are similarly distributed. Therefore, the different output and inflation responses to currency crises in higher-income and lower-income countries do not appear to be driven by different magnitudes of depreciation.

Second, there is a common perception that the world has become more ‘crisis prone’ in recent years (Bordo and Eichengreen 1999). Table 10, which shows the timing distribution of our sample of currency crises, provides just a little support for this hypothesis. Apart from a concentration of crises occurring in the early

1980s (which is about the midpoint of our sample), the distribution is fairly evenly spread, with only a slightly higher proportion of crises occurring after the early 1980s than before.

Table 9: Currency Crises by Income

Size of exchange rate depreciation

Size	Number	Proportion
Higher-income countries		
10–15 per cent	17.5	0.51
16–20 per cent	4.0	0.12
21–30 per cent	3.0	0.09
31–40 per cent	1.0	0.03
>40 per cent	9.0	0.26
Total	34.5	
Lower-income countries		
10–15 per cent	18.5	0.43
16–20 per cent	9.0	0.21
21–30 per cent	5.0	0.11
31–40 per cent	2.0	0.05
>40 per cent	9.0	0.21
Total	43.5	

Table 10: Timing of Currency Crises

Timing	Number	Proportion
1965–1970	9	0.12
1971–1975	9	0.12
1976–1980	8	0.10
1981–1985	23	0.29
1986–1990	11	0.14
1991–1995	11	0.14
1996–1998	7	0.09
Total	78	

3. The Model

3.1 The Basic Model

This section presents a familiar monetary model which rationalises some of the stylised facts about currency crises that were presented in Section 2. It is a simple variation on the framework proposed by Buiter and Miller (1982), consisting of an LM curve, a Phillips curve, an uncovered interest parity condition, and an IS curve. In steady state, domestic prices rise at the same rate as the nominal money supply: goods prices are sticky; the nominal exchange rate moves discontinuously in response to news;⁷ the monetary authority controls the rate of nominal money supply growth; and market expectations of all endogenous variables are rational. The income variable has a steady state value of zero, and so lends itself to interpretation as a measure of the output gap.

Formally, the model's behavioural equations are:

$$m - p = \kappa y - \lambda(r - r_d) \quad (3)$$

$$\dot{p} = \phi y + \mu + \alpha \left(c - \frac{\gamma r^*}{\delta} \right) \quad (4)$$

$$\dot{e} = r - r^* \quad (5)$$

$$y = -\gamma \left[r - \dot{p} + \phi \alpha \left(c - \frac{\gamma r^*}{\delta} \right) \right] + \delta c \quad (6)$$

$$l = m - p \quad (7)$$

$$c = e - p \quad (8)$$

⁷ The fact that the nominal exchange rate moves between steady states does not preclude the possibility that it could have been fixed in the initial steady state.

where:

m = (natural logarithm of) the nominal money stock;

p = (natural logarithm of) the domestic price level;

l = (natural logarithm of) real money balances;

e = (natural logarithm of) the home-currency price of a unit of foreign currency;

c = (natural logarithm of) the real exchange rate;

y = the output gap;

r = the domestic nominal bond yield;

r^* = the foreign nominal and real bond yield (exogenous);

r_d = the rate of interest on domestic money holdings (exogenous); and

$\mu = \dot{m}$ (exogenous).

These equations are standard in all but two respects. First, the opportunity cost of real balances is given, not by the lending rate of interest, but by the difference between that rate and the deposit rate of interest, r_d . Although this was a feature of the original Buiter-Miller model, its implications were not explored at length. It will feature prominently in the dynamics described below.

A more genuine innovation is our modelling of inflation. In the original Buiter-Miller model, inflation depends exclusively on the output gap and the rate of money supply growth. So, for fixed money supply growth, a nominal exchange rate depreciation only boosts inflation because it also stimulates competitiveness and output, thus leading to a movement along the short-run Phillips curve.

Section 2 suggests that this transmission mechanism does not describe currency crises very well, since prices often rise after sudden depreciations, even though output may actually fall. The missing element may be the import price inflation that follows a sudden depreciation, since this will not necessarily be related to output. To capture this, we have assumed that the inflation process is related not only to money supply growth and the output gap, but also to the difference between the real exchange rate and its equilibrium level; that is, $c(t) - \gamma^*/\delta$.⁸ In a dynamically stable economy, this aspect of the inflationary process will only be temporary. As the real exchange rate converges on its equilibrium level, the shock to import prices subsides.

It seems unlikely that inflation associated with import price pass-through would feed through into lower real domestic interest rates. Indeed, as the Asian crisis of the late 1990s demonstrates, non-financial corporations typically face sharply higher borrowing costs after sudden depreciations, especially if they have unhedged liabilities in foreign currency. We capture this rise in the real interest rate by modifying the IS equation (Equation (6)), and choosing a value of φ which is greater than one. Although this adjustment is ad hoc, it overcomes the otherwise implausible prediction of the model that economic activity will necessarily rise as a result of the rise in inflation that accompanies a currency crisis.

We consider two alternative sets of shocks to the model: a simple currency crisis, and a twin crisis. A simple crisis happens when the world interest rate rises suddenly and unexpectedly, forcing a sharp depreciation. A twin crisis follows when the rise in world interest rates and the shock to the currency force banks to stem bank runs by raising the deposit rate, r_d .

⁸ The term γ^*/δ is the equilibrium real exchange rate, for any values of α or φ .

Equations (3) through (8) collapse into the following system of equations:

$$\begin{bmatrix} \dot{l} \\ \dot{c} \end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix} -\varphi\gamma & \varphi\lambda(\gamma\alpha\varphi - \delta) - \alpha(\lambda + \gamma\kappa) \\ -1 & \lambda(\varphi\gamma\alpha\varphi - \varphi\delta - \alpha) + \kappa(\delta - \gamma\alpha\varphi) \end{bmatrix} \begin{bmatrix} l \\ c \end{bmatrix} \quad (9)$$

$$+ \frac{1}{\Delta} \begin{bmatrix} -\varphi\lambda\gamma & \alpha\gamma[\lambda(1 - \varphi\gamma\varphi) + \gamma\kappa]\delta^{-1} \\ -\lambda & [\lambda\alpha\gamma(1 - \varphi\gamma\varphi) + \gamma\kappa(\alpha\gamma\varphi - \delta) + \delta\lambda(\varphi\gamma - 1)]\delta^{-1} \end{bmatrix} \begin{bmatrix} \mu \\ r^* \\ r_d \end{bmatrix}$$

where:

$$\Delta = \lambda(1 - \gamma\varphi) + \gamma\kappa$$

This system is saddlepoint stable if its two characteristic roots are real and of opposite sign. For present purposes, this is a necessary property, since only a saddlepoint implies the discontinuous jumps in the nominal and real exchange rates which characterise currency crises. The condition which gives this saddlepoint stability, and which we assume to hold, is:

$$\frac{\alpha(\gamma\varphi\varphi - 1) - \delta\varphi}{\Delta} < 0$$

A sudden depreciation of the currency is most easily, and plausibly, generated with an unexpected rise in the world interest rate. This seems to have precipitated, or at least preceded, a number of crises in recent history. The ERM crisis of 1992 and some of the Latin American crises of the 1980s are good examples. For present purposes, we will assume the increase in the world interest rate to be unanticipated and permanent.

To simulate the banking crises that sometimes coincide with currency crises, consider the possibility of a rise in the domestic deposit rate.⁹ This takes the deposit rate above the lending rate and it is both unanticipated and contemporaneous with the rise in the world interest rate. It has the effect of making

⁹ We do not model the actual transmission of the currency crisis to the banking crisis.

some real balances unavailable for use in either consumption or investment. Of the several rationalisations that could support this assumption, we favour the possibility that the rise in world interest rates has caused some distress among domestic banks and forced them to raise rates on their liabilities in a bid to stem a bank run.

If the banking system is inter-temporally solvent, the deposit rate cannot permanently exceed the lending rate. Assume, therefore, that the deposit rate increase is of finite but uncertain duration. Specifically, the banking crisis is assumed to begin at $t = 0$, and end at a date T , determined stochastically as the outcome of a Poisson process with rate ε .

As should be clear, the endogenous variables in the model evolve over time along deterministic paths. With the arrival of any shock, there will be shifts in these deterministic paths at the time of the shock and out into the future. In the case of a banking crisis, the only uncertainty in the model once the crisis has begun arises from the assumed stochastic nature of the end of the crisis. When the crisis does end, the time-paths of the endogenous variables will shift.

We therefore introduce the notation that, for the endogenous variable x , $x(t)$ follows the deterministic path $f(t)$ while the banking crisis is occurring, for $t < T$, and the path $g(t, T)$ after the crisis has ended, $t \geq T$.

Rather than calculating the details of these deterministic paths, we focus instead on the expected value of the endogenous variables formed at the beginning of the crisis at $t = 0$, $E_0[x(t)]$, and examine how this expectation evolves over time (as t rises). To calculate $E_0[x(t)]$, we integrate over the uncertain end-date of the crisis, T :

$$E_0[x(t)] = \int_0^t \varepsilon e^{-\varepsilon T} g(t, T) dT + \int_t^\infty \varepsilon e^{-\varepsilon T} f(t) dT \quad (10)$$

The analytical solutions for the expected paths are unsightly, and they are best explained with the aid of some simple simulations. Table 11 reports a set of parameter estimates for this exercise. Although the parameters seem reasonable to us, they have been chosen more or less arbitrarily, with the satisfaction of stability

conditions in mind. Only two further comments on them seem necessary. First, the parameter φ has been set at a reasonably high level, since at lower levels the exchange rate may not overshoot, and at much higher levels, saddlepoint stability is threatened. Second, the calibration of the model gives the banking crisis an expected duration of five years.

Table 11: Simulations

Parameter	Value
κ	1.0
λ	0.3
ϕ	0.1
α	0.5 and 0.0
δ	0.2
φ	3.0
γ	0.8
μ	0
ε	0.2
dr^*	0.050 (500 basis points)
dr_d	0.075 (750 basis points) and 0.0

Figures 2 to 5 report four sets of simulation results. Figures 2 and 4 show the dynamic behaviour of the economy when there are twin banking and currency crises, while Figures 3 and 5 show the dynamics when there is no banking crisis and hence r_d is unchanged. Figures 2 and 3 show the case in which the import price effect is operative, while Figures 4 and 5 show the results from the more standard case. All results report deviations of the variables from a common baseline of zero.

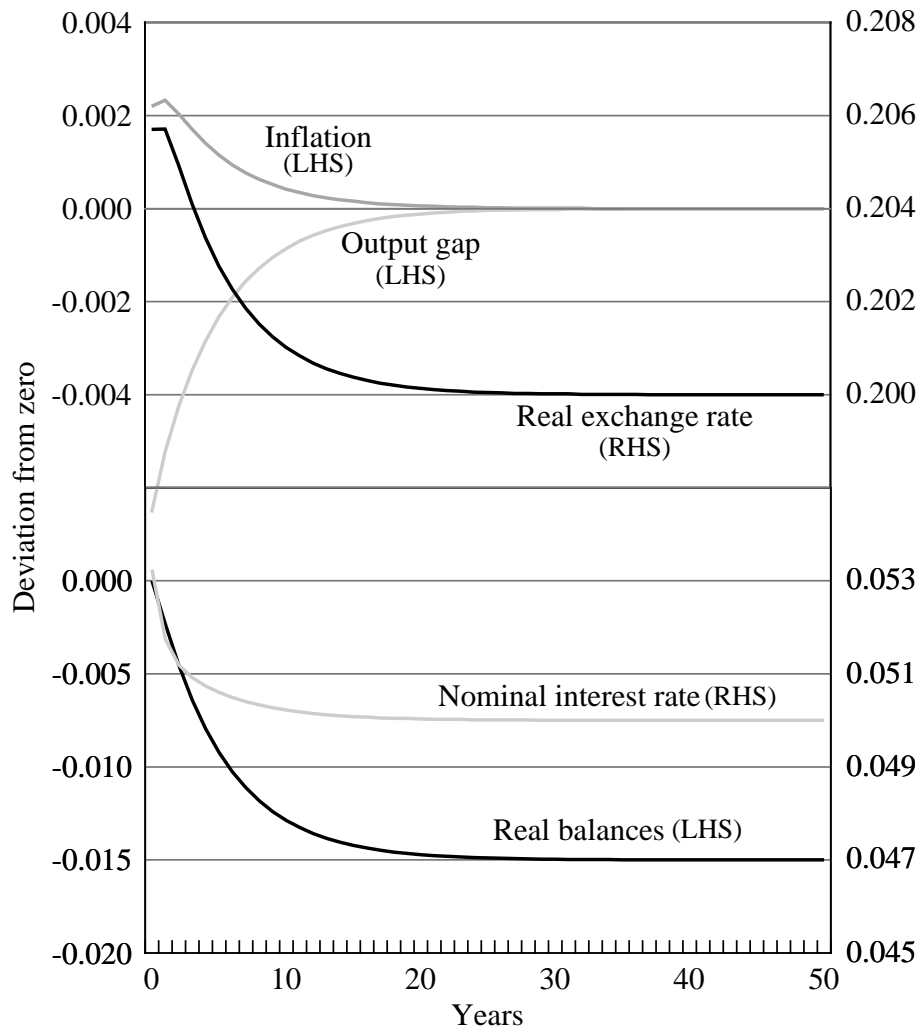
A key result is that while the nominal exchange rate depreciates in both cases, output only falls when there is a twin crisis.¹⁰ A simple increase in the world interest rate is expansionary, because it causes the nominal exchange rate to depreciate in the short run. However, if there is a banking crisis and the deposit rate of interest rises, liquidity will be withdrawn from the system and the nominal

¹⁰ Since prices are sticky, initial movements in the nominal exchange rate are identical to the movements in the real rate.

borrowing rate of interest will rise sharply. The simulations show that the contractionary effects of this rise can outweigh the stimulus from the exchange rate. The inflation outcomes also depend on whether there are simultaneous banking and currency crises, but only if there is an import price channel at work.

Figure 2: Twin Crises

$$dr^* = 0.05, dr_d = 0.075, \alpha = 0.5$$



Figures 2 and 3 show that inflation will rise after a shock and that a banking crisis will influence the extent of that rise. Figures 4 and 5 show simulations with no import price pass-through, and the outcomes are different. Currency crisis simulations show the deterministic path of variables after the crisis. Twin crisis simulations show the expectation of the variables' paths formed immediately after the crisis (at $t = 0$). In these simulations, the response of inflation is very modest, irrespective of whether or not there has been a banking crisis.

Figure 3: Currency Crisis

$$dr^* = 0.05, dr_d = 0, \alpha = 0.5$$

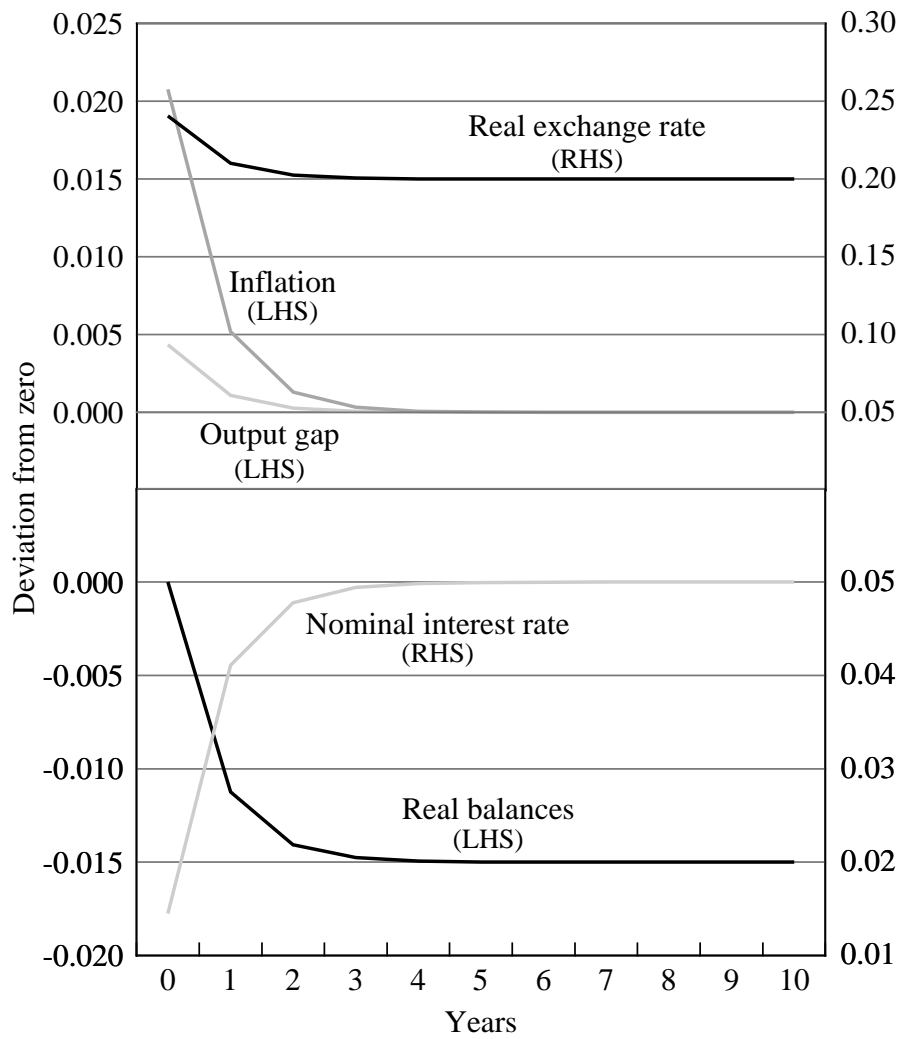


Figure 4: Twin Crises

$$dr^* = 0.05, dr_d = 0.075, \mu = 0, \alpha = 0$$

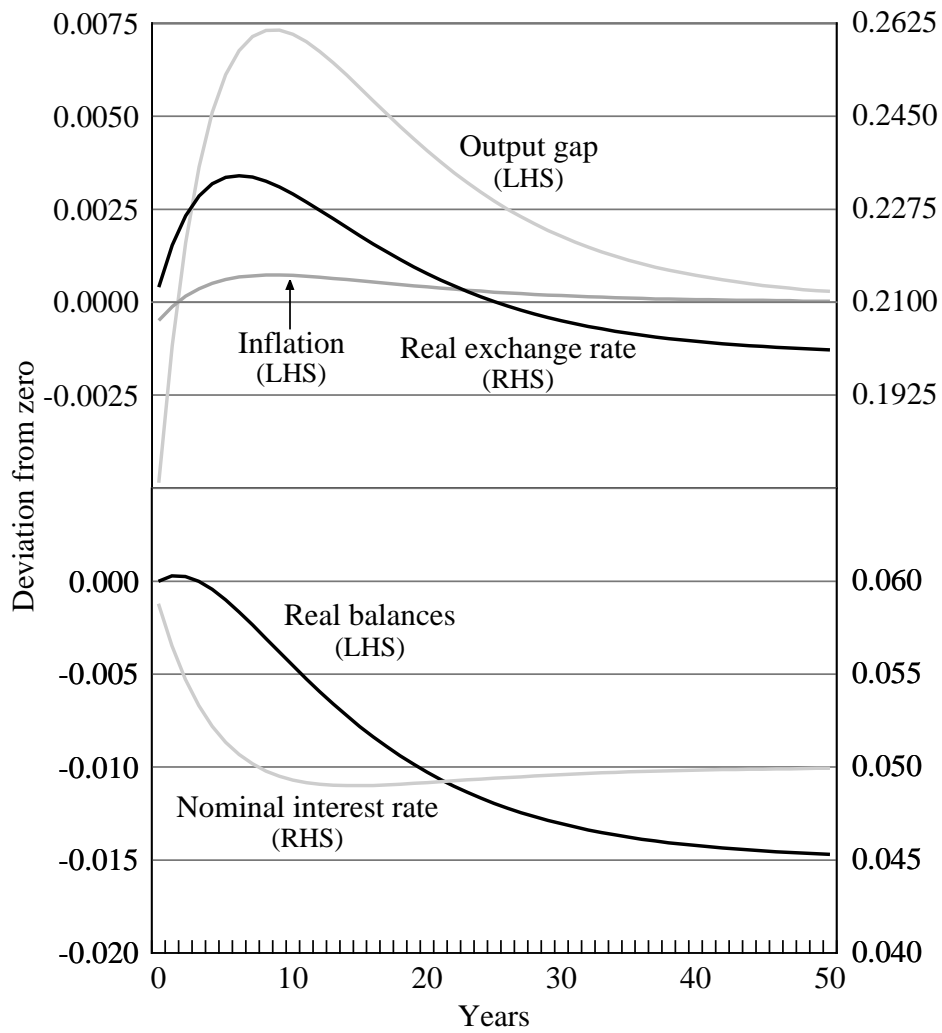
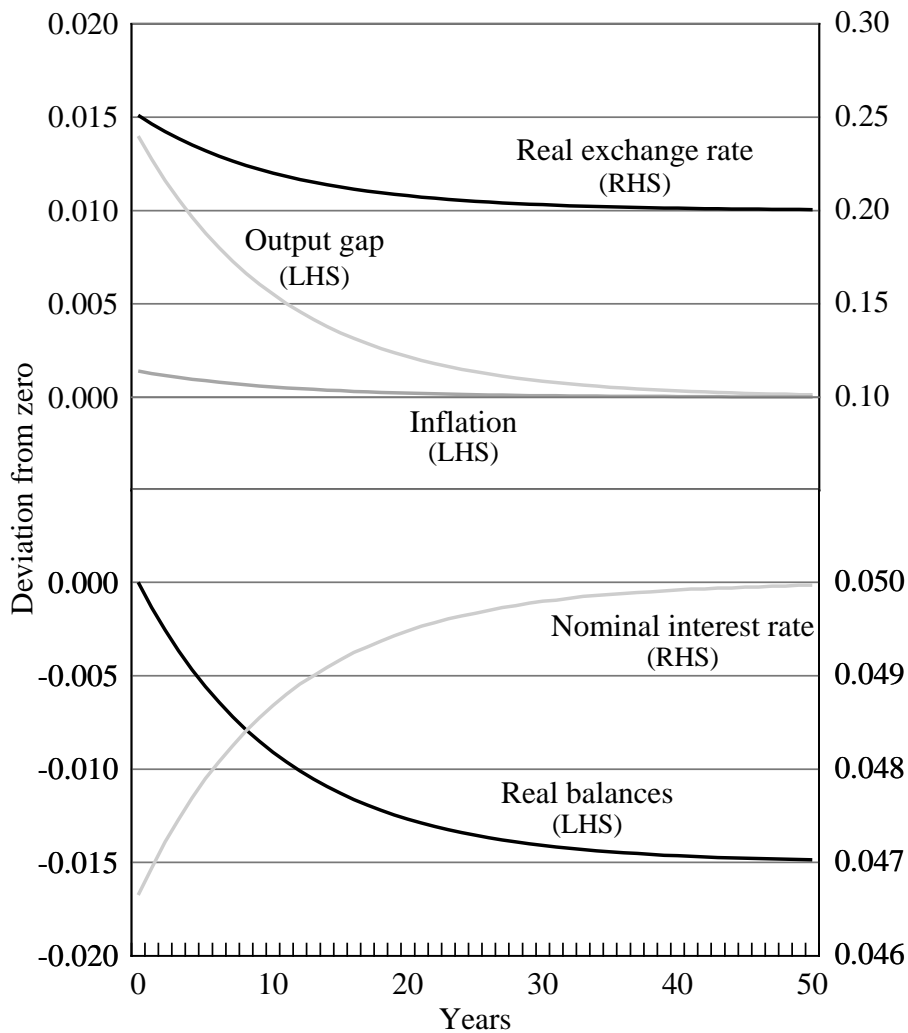


Figure 5: Currency Crisis

$$dr^* = 0.05, dr_d = 0, \mu = 0, \alpha = 0$$



3.2 Optimal Policy

After the east Asian currency crisis, there was much debate about the best monetary policy response to shocks which induce simultaneous depreciations and output contractions. Some have argued that depreciation should not be resisted in these circumstances because tighter monetary policy would probably be self-defeating (Furman and Stiglitz 1998; Stiglitz 1998). Higher interest rates may undermine the banking system and perhaps weaken confidence in the economy to the point of perpetuating, rather than easing, the depreciation to which they were addressed. Moreover, tighter policy may not be credible in the face of falling output, in which case financial markets will certainly discount or ignore it. Kraay (2000) documents some general evidence against the effectiveness of tighter

policy, showing a striking lack of correlation between interest rate settings and the outcome of speculative attacks.

The more traditional position, as stated by Fischer (1998), is that the damaging effects of depreciation on confidence and financial stability can only be arrested if the costs of short-selling the currency are raised quickly and sufficiently; that is, if monetary policy is tightened. To this, Goldfajn and Gupta (1999) add that inflation is a consideration when setting policy in the wake of a crisis. They argue that central banks should prefer to see a disequilibrium real depreciation corrected with nominal appreciation, rather than inflation. And their evidence suggests that, unless the currency crisis coincides with a banking crisis, a nominal appreciation is often achieved with tighter monetary policy.

Our model offers a formal framework which engages both the orthodox and the alternative perspectives. Assume that the rate of money growth is set by a monetary authority which takes as given the structure of the economy and the shocks to r^* and r_d . Faced with these shocks, it implements the change in the money growth rate which minimises a loss function that punishes output gaps and non-zero inflation. For the sake of simplicity, this adjustment to the money growth rate is assumed to be once-off and permanent. The problem then reduces to:

$$\underset{\mu}{\text{Min}} L = \int_0^{\infty} L(t) e^{-\nu t} dt \quad (11)$$

where:

$$L(t) = \theta [E_0 y(t)]^2 + (1 - \theta) \left[E_0 \dot{p}(t) \right]^2 \quad (12)$$

where ν and θ are preference parameters describing the discount rate and the weight that the monetary authority places on output deviations.

To solve this problem, remove the expected rate of inflation using the Phillips curve. Then assume that any change to the monetary policy rule which the shock might induce is contemporaneous with, and as unanticipated as, the changes in the two exogenous interest rates. Speculators are assumed to treat the policy change as

credible and permanent, since it represents a solution to a well-defined social welfare problem. Consistency between the policy itself and market expectations of it makes both private and public behaviour optimal.

Figures 6 through 8 show the optimal policy response (that is, the optimal choice of the money growth rate, μ) to currency and twin crises, using the parameter values in Table 11. The effects of varying θ , ν and ε on the optimal choice of μ are highlighted. In most cases, it is optimal to tighten in response to either set of shocks. However, if the monetary authority has a high discount rate, or if the banking crisis threatens to be very protracted, then the present value of lost output is high and so it can be optimal to increase the money growth rate, that is, to ease monetary policy.

Figure 6: Optimal Policy

$$dr^* = 0.05, dr_d = 0.075$$

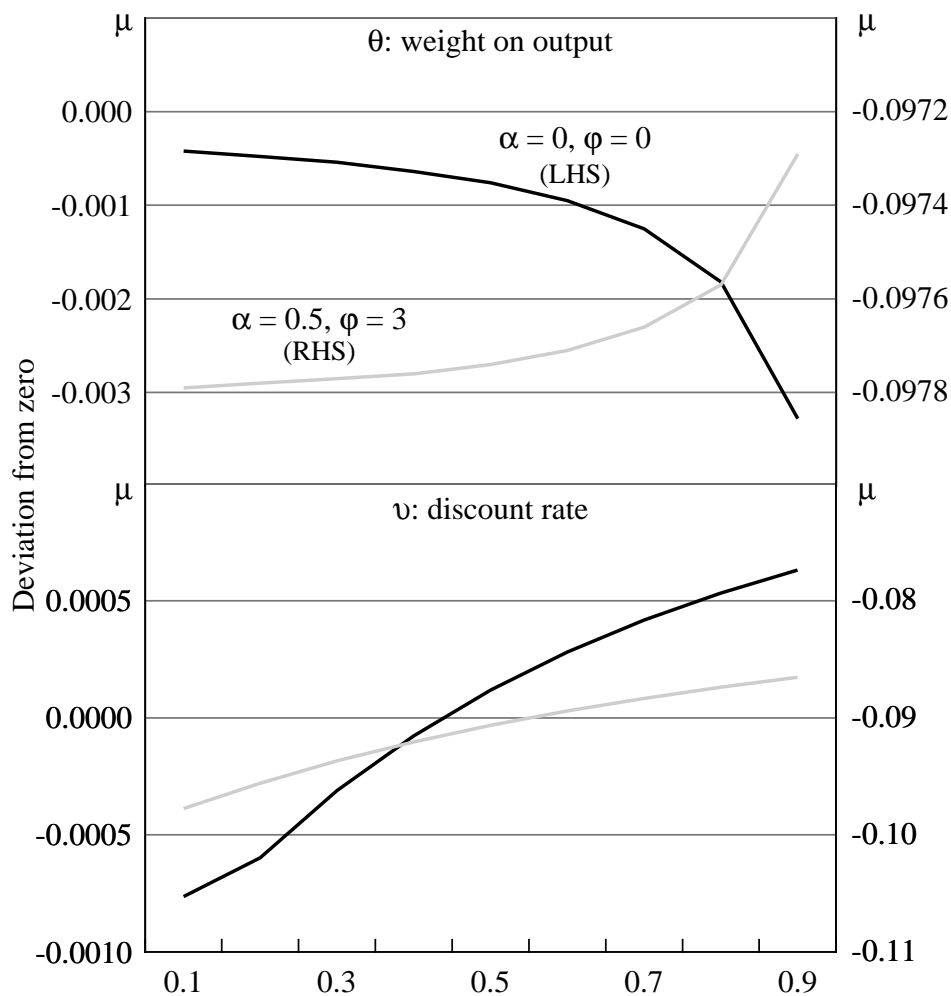
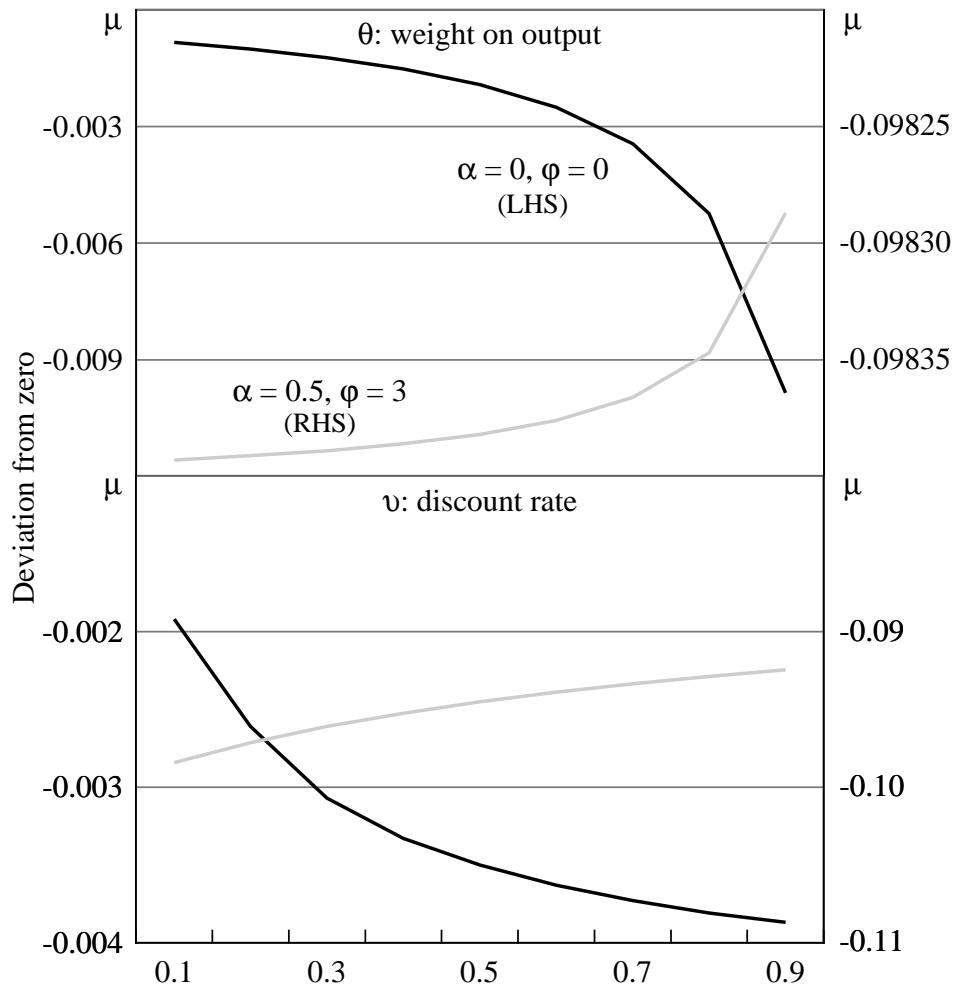
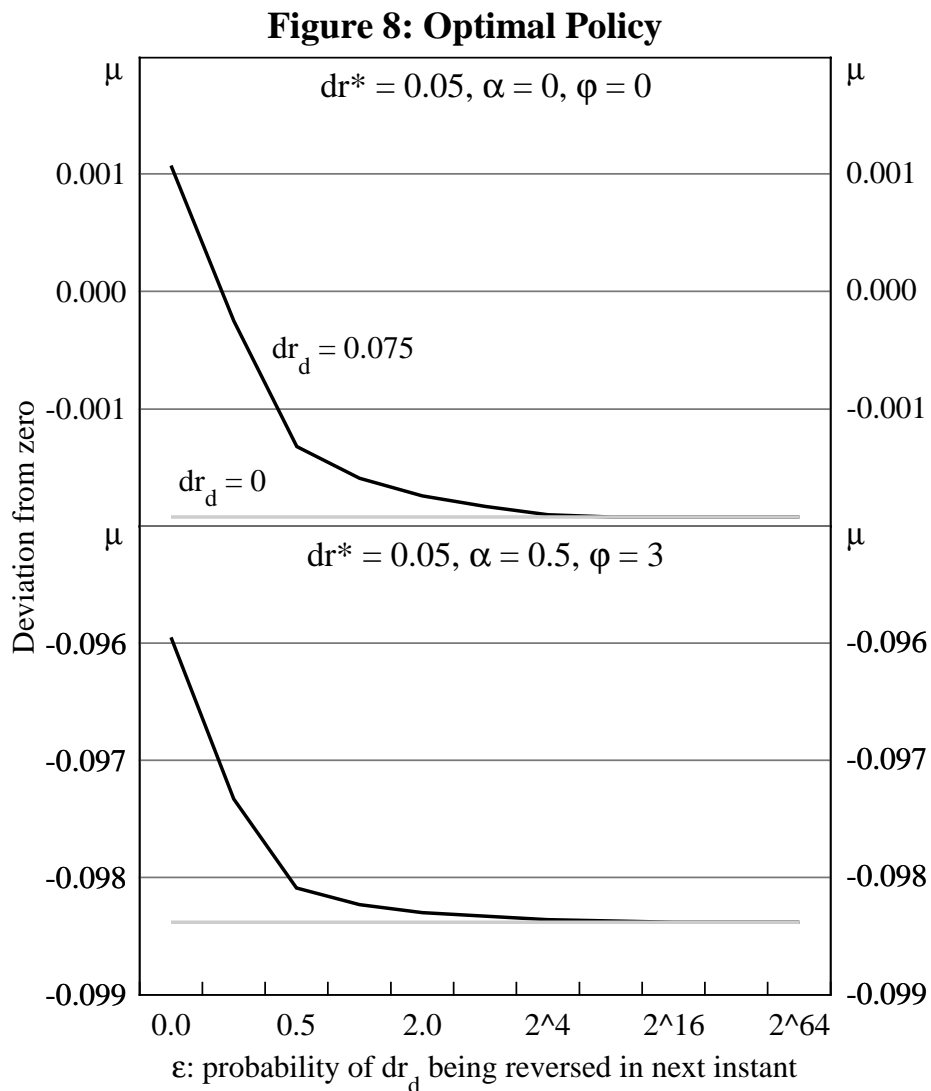


Figure 7: Optimal Policy

$$dr^* = 0.05, dr_d = 0$$

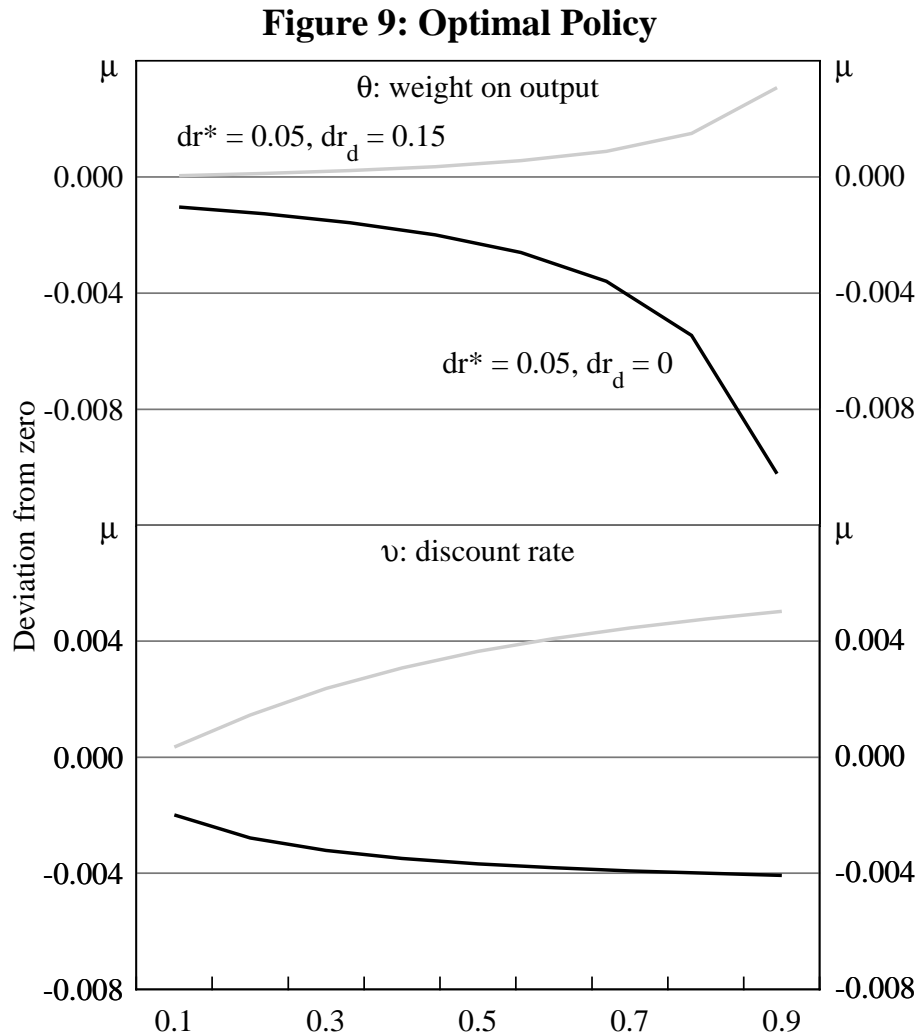




A final set of simulations highlights the sensitivity of these policy prescriptions to the differentials between the exogenous interest rates and to import price inflation. The twin crisis case assumes a 1 500 basis point increase in r_d and no direct import price inflation. The simple currency crisis case assumes a 500 basis point increase in r^* .

The optimal policies for these cases are profiled in Figure 9. They show that monetary policy depends quite heavily on the behaviour of the banking system – an easing is likely to be appropriate during a twin crisis, but unwarranted when only the world interest rate rises. In the twin crisis case, the opening of a large differential between the two domestic interest rates tends to push output down

heavily, while a subdued inflation response removes any incentive which the monetary authority may otherwise have had to tighten.



These final results accord reasonably well with the conclusions of Aghion, Bacchetta and Banerjee (2000). Using a model which is simpler than, but broadly similar to, ours, Aghion *et al* find that it may well be optimal to ease policy when the financial system is distressed by the crisis, and when the proportion of foreign currency denominated corporate debt is high.

4. Conclusion

This paper has reviewed international evidence on the effects of sudden nominal depreciations, and it has presented a framework for considering macroeconomic

dynamics in the wake of a currency crisis. In many of the crises in our sample, output fell in response to a sudden depreciation, while the inflation response was mixed. Both the data and the formal modelling drew attention to the role of banking crises in these situations.

The model has several implications for policy. Formally, it showed that the optimal monetary policy response to a crisis depends upon the condition of the banking sector. Currency crises that cause, or coincide with, banking crises are different to those which are characterised by a simple opening of the international interest differential. Because twin crises are more likely to produce interest rate rises which overshadow the improved competitiveness that would normally flow from a depreciated exchange rate, they can produce declines in output.

Appendix A: Sample of Currency and Twin Crises

Table A1: Higher-income Countries	
Above median per capita income at 1982 sample midpoint	
Country	Crises
Argentina	1966:M11; 1970:M6; 1975:M1; 1981:M2*
Australia	1974:M10; 1976:M12; 1985:M2
Bulgaria	1996:M5*
Colombia	1965:M9
Finland	1982:M10; 1992:M9*
France	1969:M8
Greece	1983:M1
Ireland	1967:M12
Israel	1974:M11; 1977:M11*; 1989:M1
Mexico	1982:M2*; 1994:M12*
Portugal	1982:M6
Spain	1977:M7*
Sweden	1982:M10; 1992:M11*
Trinidad and Tobago	1985:M12; 1993:M4
United Kingdom	1967:M12; 1992:M10
Uruguay	1971:M12; 1982:M12*
Venezuela	1984:M2; 1986:M12; 1989:M3; 1995:M12*
South Africa	1975:M10; 1984:M7

Note: * denotes twin crises

Table A2: Lower-income Countries
Below median per capita income at 1982 sample midpoint

Country	Crises
Bolivia	1972:M11; 1979:M12; 1982:M2
Botswana	1984:M7; 1992:M7; 1998:M7
Costa Rica	1981:M1
Dominican Republic	1985:M1; 1987:M6; 1990:M4
Ecuador	1970:M8; 1982:M5*; 1985:M12; 1992:M9
Guatemala	1986:M6; 1989:M11; 1997:M1
Hungary	1991:M1*
Indonesia	1978:M11; 1983:M4; 1986:M9; 1997:M8*
Jamaica	1967:M12; 1973:M1; 1978:M5; 1983:M11
South Korea	1971:M7; 1974:M12; 1980:M1; 1997:M11*
Mauritius	1967:M12; 1979:M11; 1981:M10
Peru	1987:M11
Philippines	1983:M10*; 1997:M9
Poland	1991:M6*
Paraguay	1984:M3; 1986:M12; 1989:M3
Thailand	1984:M11*; 1997:M7*
Turkey	1991:M3*

Note: * denotes twin crises

References

Aghion P, P Bacchetta and A Banerjee (2000), ‘A simple model of monetary policy and currency crises’, *European Economic Review*, 44(4–6), pp 728–738.

Bordo M and B Eichengreen (1999), ‘Is Our Current Economic Environment Unusually Crisis Prone?’, in D Gruen and L Gower (eds), *Capital Flows and the International Financial System*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 18–74.

Buiter WH and M Miller (1982), ‘Real Exchange Rate Overshooting and the Output Cost of Bringing Down Inflation’, *European Economic Review*, 18(1–2), pp 85–123.

Caprio Jr G and D Klingebiel (1996), ‘Bank Insolvency: Bad Luck, Bad Policy, or Bad Banking?’, in M Bruno and B Pleskovic (eds), *Annual World Bank Conference on Development Economics*, World Bank, Washington DC, pp 79–104.

Demirgüç-Kunt A and E Detragiache (1997), ‘The Determinants of Banking Crises: Evidence from Developing and Developed Countries’, World Bank Policy Research Working Paper No 1828.

Fischer S (1998), ‘Reforming World Finance: Lessons from a Crisis’, *The Economist*, October 3–9, pp 19–23.

Furman J and JE Stiglitz (1998), ‘Economic Crises: Evidence and Insights from East Asia’, *Brookings Papers on Economic Activity*, 2, pp 1–114.

Goldfajn I and P Gupta (1999), ‘Does Monetary Policy Stabilize the Exchange Rate Following a Currency Crisis?’, IMF Working Paper No WP/99/42.

Hausmann R, U Panizza and EH Stein (2000), ‘Why do Countries Float the Way They Float?’, Inter-American Development Bank Working Paper No 4/8.

Hutchison MM and K McDill (1998), 'Determinants, Costs and Duration of Banking Sector Distress: The Japanese Experience in International Comparison', available at <<http://econ.ucsc.edu/~hutch/>>.

IMF (International Monetary Fund) (1998), *World Economic Outlook*, May.

Kaminsky G and CM Reinhart (1996), 'The Twin Crises: The Causes of Banking and Balance-of-Payments Problems', International Finance Discussion Papers No 544.

Kraay A (2000), 'Do High Interest Rates Defend Currencies During Speculative Attacks?', World Bank Policy Research Working Paper No 2267.

Stiglitz JE (1998), 'Knowledge for Development: Economic Science, Economic Policy and Economic Advice', in B Pleskovic and JE Stiglitz (eds), *Annual World Bank Conference on Development Economics*, World Bank, Washington DC, pp 9–58.