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FINANCIAL CRISES, MONETARY POLICY AND FINANCIAL FRAGILITY; A SECOND-GENERATION MODEL OF CURRENCY CRISES

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ABSTRACT

Financial Crises, Monetary Policy and Financial Fragility; A Second-Generation Model of Currency Crises*

In this Paper we present a model that combines the second-generation trade-off between costs of maintenance and abandonment with possible balance-sheet problems in the corporate sector. We show how debt levels can move a small economy from a fixed exchange rate to a floating exchange rate equilibrium or *vice versa*, simply by altering the trade-off faced by the monetary authorities. Even if the monetary authorities still have a substantial amount of foreign reserves available to guarantee the fixed value of the currency, they might choose not to and abandon the fixed exchange rate regime. Although it is often argued that first- and second-generation literature have not been able to explain the crisis in East Asia (1997-98), our model suggests that adding corporate balance sheet positions to second-generation models could substantially improve the explanatory power of these models in the case of the Asian crisis.

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1 Introduction

The history of currency crises goes back a long time. It was already in 1863, that the author Joseph Holbrey, in response to a crisis in England in 1857, expressed his desire to identify their cause and find the most likely remedy. From his conclusions it follows that currency crises were no less harmful in those periods than they are today: "The present system, every now and then, brings a crisis which carries ruin and desolation to many who are innocent, as well as to those who are more or less guilty; while it is the cause of wide-spread misery to both, it is not, even to the guilty, in proportion to their guilt."[1] In the last three decades, many countries and regions around the world have suffered from minor or major currency crises. Mexico ('73-'82) and Argentina ('78-'81) were early examples. In the nineties, several countries in Europe ('92-'93), again Mexico ('94-'95), East Asia ('97-'98), Russia ('98), and Brazil ('99) followed. More recently, Turkey ('00-'01) and Argentina ('01-'02) were hit by this painful event.

Although these crises have already been subject to many debates among both policymakers and academics, their origin remains the source of much controversy. From an academic perspective, an extensive economic literature has evolved, both theoretical and empirical. The traditional theoretical literature consists of two major views, represented in respectively first-, and second-generation models of currency crises. First-generation literature was developed in response to crises in developing countries such as Mexico (1973-1982) and Argentina (1978-1981). Both crises were preceded by periods of overly expansive domestic policies combined with more or less fixed exchange rate regimes. First-generation models derive from work done by Salant and Henderson (1978), who discussed the consequences of price stabilization schemes in commodity markets. Such price stabilization, through the buying and selling of commodity reserves, will sooner or later lead to severe speculative attacks and depletion of reserves, according to the authors. It was not long before others[2] realised that the concept of exhaustible resources could also be applied to a central bank attempting to fix the exchange rate by selling and buying foreign currency. In both cases, the government attempts to stabilise the price of an exhaustible resource by using reserves. The first-generation models explain currency crises as the result of the inconsistency between internal and external government policies. More in particular, the combination of structural government deficits and a fixed exchange rate leads to depletion of foreign reserves, eventually resulting in crisis.

The crucial feature of second-generation literature[3], which was developed in response to crises in Europe (1992-1993) and, again, Mexico (1994-1995), is the recognition that the maintenance or collapse of a fixed exchange rate is a matter of trade-off rather than a simple process of foreign reserve depletion. Not only does the question of whether to maintain a fixed exchange rate regime

[1] Holbrey (1863), p. 366

[2] First-generation models are probably best represented by Krugman (1979) and Flood and Garber (1984).

[3] For a leading example of second-generation models please refer to Obstfeld (1994).

involve costs and benefits, second-generation models assume that the costs of maintenance increase when people expect a collapse. As a consequence, the policy of the government is no longer exogenous but depends, among other things, on the market's beliefs about the future. Under specific circumstances, this can lead to multiple equilibria and self-fulfilling expectations in the course of which the very existence of these expectations determines the equilibrium that prevails.

Although first- and second-generation models have considerable relevance to crises in the past, it is often argued[4] that they have not been able to explain the crises in the countries of East Asia ('97-'98). The governments of these countries did not experience any first-generation alike fiscal problems at that time nor did any of them face the clear trade-off between exchange rate stability and unemployment that featured several countries in the EMS in '92 and '93. As a result, it seemed that, to explain the Asian crisis, a 'third-generation' model was needed. Most of the attempts to produce such a model focused on the financial sector as being the cause of the crisis. Krugman (1998) and Corsetti, Pesenti, and Roubini (1998a, 1998b) for example, argued that implicit government guarantees led to an excessive level of investment which after some time collapsed when governments were no longer willing or able to cover the losses. Alternatively, Chang and Velasco (1998a, 1998b) concentrated, analogue to Diamond and Dybvig (1983), on a shortage of liquidity in the banking system caused by a loss of confidence among investors. More recently, several authors have emphasised the role of firms' balance sheets in the origin of crises.[5]

In this paper we present a model that combines the second-generation trade-off between costs of maintenance and abandonment with possible balance-sheet problems in the corporate sector. More specifically, we show how the levels of (consolidated) domestic currency denominated and foreign currency denominated short-term debt influence the trade-off that the central bank faces when deciding whether to defend a currency peg. Depending on these debt levels, the probability of an exchange rate collapse may alter. Even if the monetary authorities still have a substantial amount of foreign reserves available to guarantee the fixed value of the currency, they might choose not to and abandon the fixed exchange rate regime.

Especially in the light of the crisis in Asia, the appropriate reaction of monetary authorities to speculative attacks has been the source of much controversy. According to the so-called 'traditional view', tighter monetary policy was needed to defend the fixed value of the currency and restore market confidence. This was also the policy that the IMF initially prescribed. On the other hand, a 'revisionist view' emerged, which argued that when speculative attacks are accompanied by substantial balance-sheet problems in the financial and corporate sectors, raising interest rates may actually have a reverse effect on the level of the exchange rate. In this respect, the high debt/equity ratios in the corporate sector of several Asian crisis countries at the time of the crisis are remarkable.

[4] Refer to for example Krugman (1999)

[5] For example, Krugman (1999)

Especially when compared to the pre-crisis period in Mexico in 1994, when this country was facing interest rates as high as 75 % (annually) without collapsing, the Asian economies were more vulnerable because their corporations were much more highly leveraged. A number of recent empirical studies have attempted to find evidence on the effect of tightening monetary policy on the level of the exchange rate. Neither the 'traditional view' nor the 'revisionist view' are supported by conclusive evidence, although this may partly be the result of methodological problems.[6]

2 The model

We use an extended version of the Dornbusch[7] sticky-price monetary model for the exchange rate to study a small open emerging-market economy[8]. The Dornbusch model has a number of widely celebrated features. First, it is a simple and elegant model. Second, given a permanent shock to the economy, it distinguishes between a 'short run' horizon, during which only financial variables (interest rate and exchange rate) adjust, and a 'long run' horizon, during which the price level begins to adjust. Third, the model assumes that market participants have perfect foresight when it comes to this adjustment process. Finally, the Dornbusch model contains the famous 'overshooting' result where a monetary expansion causes the exchange rate to overshoot its long-run equilibrium level[9] in the short run before appreciating back towards it in the long run.

For simplicity, our model is limited to two subsequent periods: period t and period t+1. We assume that prices are sticky in period t ('short run') and fully adjust in period t+1 ('long run') in order to maintain equilibrium in the money and goods markets. Initially, the monetary authorities maintain a fixed exchange rate. This implies that, unlike in the Dornbusch model, monetary policy cannot be set autonomously but has to guarantee the currency peg at all times. In the case where the fixed exchange rate is abandoned, monetary policy is no longer restricted and can be set freely. However, in period t+1, the price level will adjust in proportion to period t and expected period t+1 changes in the money supply. Market participants are assumed to form rational expectations. They dispose of the same information as the monetary authorities. Our model assumes that, given that domestic and foreign debt ratios[10] remain at their natural levels[11], market participants and the monetary authorities have perfect

[6] Refer to for example Furman and Stiglitz (1998), Kraay (2000), Goldfajn and Baig (1998), Goldfajn and Gupta (1999), and Gould and Kamin (2000).

[7] Dornbusch (1976)

[8] The small open character of the economy in our model follows from the assumption that the 'foreign interest rate' is assumed exogenous. This 'large' foreign economy in our model represents either the 'rest of the world' or the main trading partner of the home country.

[9] The long-run equilibrium level is determined by purchasing power parity.

[10] domestic debt denotes domestic currency denominated short-term debt, assumed to be subject to the variable domestic short-term interest rate controlled by the monetary authorities; foreign debt denotes foreign currency denominated debt (for reasons of simplicity we do not distinguish between short-term and long-term foreign debt)

[11] The 'natural' level of the domestic and foreign debt ratios is assumed exogenous and equal

foresight on the path of the economy. However, possible deviations of the debt levels in period t cannot be foreseen in advance. Therefore, when setting the price level for period t, market participants base themselves on the expectation that debt will still be at its natural level.[12] When setting monetary policy in period t, the monetary authorities take account of possible deviations of the debt levels and will adjust monetary policy accordingly.

In this section we will present the basic model and, subsequently, the dynamics of the model. Symbols that are marked by asterisks pertain to foreign variables and are assumed exogenous.

$$
\begin{aligned}
M_t - \bar{p}_t &= \gamma - \beta\ (i_t - RP_t) && (1)\\
y_t &= y_n - \lambda\ (r_t - r_n) + \theta\ (S_t - p_t) && (2)\\
r_n &= r^* = c && (3)\\
i_t &= i^* + (S_{t+1} - S_t) + RP_t && (4)\\
S_{t+1} &= p_{t+1} && (5)\\
i_t &= r_t + \dot{p}_{t+1} && (6)
\end{aligned}
$$

where γ, β, λ, θ,and c are strictly positive constants.

Notation

All variables in logarithms; in the remainder of the paper, we will use a circumflex to denote the non-logarithmic form of the variables (e.g. $\hat{M_t}$), unless mentioned otherwise.

M_t	domestic nominal money supply in period t
$\bar{p}_t$	domestic price level in period t (fixed)
i_t	(1+i_t), where i_t denotes the domestic nominal interest rate in period t
RP_t	(1+RP_t), where RP_t denotes the default risk premium on domestic debt relative to foreign debt in period t
y_t	domestic real output in period t
y_n	natural level of domestic real output
r_t	(1+r_t), where r_t denotes the domestic real interest rate in period t
r_n	(1+r_n) where r_n denotes the natural domestic real interest rate

to the ratio's in the 'foreign country'. Later on it will be explained that the risk premium on domestic debt titles is in our model a relative risk premium as it denotes only the *difference* between the risk premium on foreign and domestic debt titles.

[12] One could argue here that deviations of debt levels have never occurred before or are mean-zero distributed.

r^*	(1+r*), where r* denotes the foreign real interest rate (fixed)
S_t	exchange rate in period t (initially fixed), defined as the price of foreign currency in terms of home currency
i^*	(1+i*), where i* denotes the foreign nominal interest rate (fixed)
S_{t+1}	exchange rate in period t+1 corresponding to the maturity of the interest rate
$\dot{p}_{t+1}$	level of inflation in period t+1 ($= p_{t+1} - \bar{p}_t$)

Equation (1) represents equilibrium in the domestic money market. The demand for real money balances is assumed to depend on the domestic interest rate less the risk premium and will, in equilibrium, equal the real money supply. Since we assume risk neutrality, market participants are only interested in the *expected* return on domestic assets[13]. Equation (2) denotes goods market equilibrium. Our model assumes demand determined output in the short run. Deviations of the real interest rate from its natural level and the exchange rate from its purchasing power parity (PPP) level[14] may cause a deviation of output from its natural level. The former reflects the discouraging effect of higher interest rates on investment as part of aggregate demand. The latter indicates that aggregate demand is rising with the level of the real exchange rate, $S_t - p_t$. This is under the assumption that a real depreciation of the domestic currency shifts world demand towards home-produced goods. Equation (3) states that the natural real interest rate equals the (fixed) foreign real interest rate. We assume that the debt levels and the price level in the foreign country are permanently fixed. Furthermore, we assume that the foreign real interest rate, which equals the foreign nominal interest rate, is strictly positive. This can reflect either a capital market equilibrium with a strictly positive marginal product of capital or a strictly positive risk premium corresponding with the fixed debt levels in the foreign country.[15] Equation (4) shows a revised version of the uncovered interest rate parity condition. Since we study a small open emerging market economy, we assume, unlike Dornbusch, imperfect substitutability of domestic and foreign debt titles. This assumption reflects the real world observation that emerging markets often face a higher risk premium ('spread') on their foreign loans than industrialised countries[16]. As in Dornbusch, our model assumes perfect capital mobility and rational expectations. In order for risk neutral investors to be indifferent between domestic and foreign debt titles, the expected nominal returns on both assets - adjusted for default risk and the corresponding risk premium

[13] The risk premium only compensates for the possible monitoring costs in case of default and therefore does not add to the expected return on domestic debt titles. Monitoring costs may arise due to asymmetry of information between lenders and borrowers. Section 2.2 deals extensively with the risk premium. For now, we will leave it aside.

[14] The log of the foreign price level is assumed to be zero.

[15] Recall that the risk premium, as defined in our model, only relates to the *relative* default risk of domestic debt titles versus foreign debt titles. We leave the possible positive *absolute* risk premium in the foreign country aside. Section 2.2 gives a more extensive explanation of the risk premium in our model.

[16] This 'spread' could also be related to exchange rate risk. However, in our model we assume the exchange rate risk to be symmetric. As a consequence, given the risk neutrality of market participants, no risk premium is required for the exchange rate risk.

- have to be equal. Therefore, the domestic nominal interest rate equals the sum of the (fixed) foreign nominal interest rate, the expected depreciation[17] of the domestic currency, and the required risk premium for the relatively higher default risk on domestic debt. Equation (5) represents the assumption of purchasing power parity in period t+1. Since the price level is flexible in period t+1, it will depend, amongs other things, on monetary policy in period t. However, both in the case of maintenance as in the case of abandonment of the peg in period t, the nominal exchange rate will equal the price level in period t+1. Equation (6) illustrates that the nominal interest rate in period t+1 equals the sum of the real interest rate and the level of inflation in period t+1.

2.1 Dynamics of the model

As explained above, our model considers two periods: period t and period t+1. We assume that, prior to period t, the monetary authorities have been running a fixed exchange rate regime. The economy is assumed to be in long-run equilibrium with output being equal to its natural level. At the beginning of period t, market participants set prices according to their expectations of monetary policy in that period.[18] Since the peg has been viable up till period t and deviations of the domestic and foreign debt levels are expected to be zero, the period t price level will simply equal its level from the previous period. In other words, market participants expect the fixed exchange rate regime to be maintained throughout period t, implying that the money supply will be kept unchanged. After prices have been set, the monetary authorities observe the domestic and foreign debt levels and, subsequently, choose monetary policy by minimising its loss function. Our model will show that the maintenance or abandonment of the fixed exchange rate regime depends, amongst other things, on the possible deviations of debt levels from their natural levels. Section 2.3 deals with the preferences of the monetary authorities. Returning to equations (1) and (4), maintenance or abandonment determines the causality in our model. In case of maintenance, the causality runs from the right-hand side of the uncovered interest parity condition (4) to the left-hand side of the money market equilibrium condition (1). If it is no longer optimal to support the peg, monetary policy is no longer restricted and the monetary authorities will set monetary policy so as to minimise their loss function in the current period. In this case causality runs from the left-hand side of the money market equilibrium (1) to the right-hand side of the uncovered interest parity condition (4).

In period t+1, prices are fully flexible and the economy reaches its long run steady-state equilibrium. We assume that possible deviations of the debt levels only last throughout period t. Furthermore, as stated before, we assume that, given the domestic and foreign debt levels, market participants and the monetary authorities have perfect foresight on the path of the economy. This implies that they foresee, amongst other things, the time path of monetary

[17] Note that, as we assume perfect foresight and long-run equilibrium in period t+1, we can write S_{t+1} for the expected t+1 exchange rate.

[18] For simplicity, we will not distinguish between consumers and producers.

policy. Given the monetary policy stance in period t (either maintenance or collapse), they are therefore able to set their t+1 prices so as to ensure steady state equilibrium in the money and goods markets. In other words, monetary policy is neutral in the long run.

2.2 Financial fragility and the risk premium

As stated in the introduction, our model illustrates how the trade-off between costs of maintenance and abandonment depends on the degree of financial fragility in the economy. In our model, financial fragility relates to the state of the balance sheets in the corporate sector. More in particular, we define financial fragility as the degree to which the net worth of the corporate sector is vulnerable to increases in the domestic interest rate and/or devaluations of the currency. Higher financial fragility therefore corresponds to higher levels of (consolidated[19]) domestic short-term debt and/or higher levels of (consolidated) foreign debt. The level of financial fragility influences the monetary authorities 'trade-off ' through the risk premium.

2.2.1 The risk premium

As explained before, we assume imperfect substitutability of domestic and foreign debt titles. As a consequence, the difference between the domestic and foreign nominal interest rates not only has to cover for a future change in the nominal exchange rate, but also has to compensate for the difference in risk premiums on debt titles in both countries. The microeconomic underpinning of the risk premium that we use in our model follows from Céspedes, Chang, and Velasco (2000) and Bernanke, Gertler, and Gilchrist (1998). A crucial element in the analysis is the assumption of asymmetric information between borrowers and lenders of capital. Borrowers have complete insight into the returns of investments whereas lenders cannot observe these returns unless they pay a proportional monitoring cost. Referring to Williamson (1987), the authors assume an 'optimal' standard debt contract in which a fixed repayment is laid down. As long as borrowers pay off their debt, lenders have no incentive to monitor the realised return on investment. However, if borrowers renege on the debt contract, lenders will monitor the outcome and claim the whole return on investment. The question of whether borrowers can meet their obligations depends on the realised return on investment, which Céspedes et. al. assume to be independently and identically distributed. Given the level of debt and the required return on this debt, one can determine a minimum threshold level of the realised return for which the borrower is still able to pay off his debt. If the realised return falls short of this minimum level, bankruptcy will follow shortly thereafter and the lender will have to incur monitoring costs. These possible costs of monitoring give rise to the existence of a risk premium on debt titles.

[19] We assume the supply side of the domestic economy to consist of a positive number of identical firms. The equations hereafter not only apply to firms at the individual level but also refer to the entire economy at the consolidated level.

The level of these expected monitoring costs is shown to be depending on the level of investment relative to the level of net worth of the borrower[20]. The higher the proportion of net worth in total investment, the lower the part of the investment that is externally financed, and the lower the minimum threshold value of the realised return for which the borrower can still repay his debt. After all, in case of a disappointing outcome, the borrower can draw more heavily on reserves to meet his obligations. Given the distribution of the realised returns, a lower threshold value implies a lower probability of bankruptcy and correspondingly, lower expected monitoring costs and a lower risk premium. Formally, we assume that the risk premium is simply given by:

$$\begin{aligned} \ln \ Risk\ Premium_t &= \ln \left(\frac{Investment_t}{Net\ Worth_t} \right) \\ &= \ln Investment_t - \ln NetWorth_t \end{aligned} \tag{7}$$

All variables in non-logarithmic forms.

Equation (2) showed that the level of (real) investment is negatively related to the deviation of the real interest rate from its natural level. For simplicity, we assume the level of investment in (7) to be given by:

$$\ln \ Investment_t \ = \ \psi - \delta \ (r_t - r_n) \tag{8}$$

where ψ and δ are positive constants.

Endogeneity of net worth The risk premium, which is part of the real interest rate, depends on the level of (real) net worth. However, net worth itself also depends on the level of the interest rate. As real domestic debt is subject to the short-term real interest rate - that is under control of the monetary authorities - raising this interest rate will have a positive effect on the real amount of money that borrowing firms have to repay at the end of the period. As a consequence, the real present value of debt increases and, for a given value of total assets, the level of real net worth will fall. Next to the domestic interest rate, net worth also depends on the level of the real exchange rate. As foreign debt is denominated in foreign currency, the real domestic currency value of foreign debt, and consequently, the level of real net worth, varies with the level of the real exchange rate.

Formally, the relation between the interest rate and net worth can be defined as follows:

$$\ln \ Net\ Worth_t = \ln \ (\hat{\phi}_t \ - \ \hat{r}_t \ \hat{d}_t^d \ - \ (\frac{\hat{S}_t}{\hat{S}^{fix}}) \ \hat{d}_t^f) \tag{9}$$

[20] The borrower can be viewed as an entrepreneur.

$\hat{\phi}_t$	consolidated total assets at the beginning of period t (equal to the sum of debt and net worth)
$\hat{d}_t^d$	consolidated domestic debt at the beginning of period t, maturing in 1 period.
$\hat{S}^{fix}$	level of the (initially) fixed exchange rate at the beginning of period t.
$\hat{d}_t^f$	consolidated foreign debt at the beginning of period t.

Absolute versus relative risk premia Integrating (8) and (9) into (7) yields:

$$\ln \ Risk\ Premium_t \ = \psi \ - \ \delta\,(r_t - r_n) \ - \ \ln\ (\hat{\phi}_t \ - \ \hat{r}_t\, \hat{d}_t^d \ - \ (\frac{\hat{S}_t}{\hat{S}^{fix}})\ \hat{d}_t^f) \quad (10)$$

Equation (3) stated that the natural real interest rate equals the (fixed) foreign real interest rate (equal to c). This reflects the assumption that the foreign economy is permanently in long-run equilibrium. This equilibrium is identical to the period t-1 equilibrium in the home country. The price level is fixed and, additionally, we assume the ('natural') domestic and foreign debt levels to be equal to zero. In footnotes 11 and 15 we already distinguished between absolute risk premia in the home and foreign country and the relative risk premium, being the difference between the domestic and foreign risk premia. The variable RP_t, as laid down in equations (1) and (4), refers to the relative risk premium, which can be determined as follows.

The absolute domestic risk premium simply equals the risk premium as given by equation (10). The absolute foreign risk premium can be defined by integrating the assumptions above into (10):

$$\ln\ absolute\ foreign\ risk\ premium_t \ = \psi \ - \ \ln \hat{\phi}_t \quad (11)$$

For simplicity, we assume that the absolute foreign risk premium equals zero. As a consequence, the foreign real interest rate equals c. The relative risk premium, ${RP_t}$[21], can be found by subtracting (11) from (10):

$$RP_t \ = \ - \ \delta\,(r_t - r_n) \ - \ \ln\ (1 - \ \hat{r}_t\, \frac{\hat{d}_t^d}{\hat{\phi}_t} \ - \ (\frac{\hat{S}_t}{\hat{S}^{fix}})\ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \quad (12)$$

Using the approximation $\ln(1 + x) \approx x$ we can rewrite (12) as:

$$RP_t \ = \ - \ \delta\,(r_t - r_n) \ + \ \hat{r}_t\, \frac{\hat{d}_t^d}{\hat{\phi}_t} \ + \ (\frac{\hat{S}_t}{\hat{S}^{fix}})\ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \quad (13)$$

With the same approximation, $\hat{r}_t$ can be written as $(1 + r_t)$ and $(\frac{\hat{S}_t}{\hat{S}^{fix}})$ can be rewritten as $(1 + S_t - S^{fix})$:

[21] Recall that RP_t denotes the logarithm of $(1+\mathrm{RP}_t)$, where RP_t denotes the default risk premium on domestic debt relative to foreign debt in period t.

$$RP_t \;=\; -\;\delta\,(r_t - r_n) \;+\; (1+r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} \;+\; (1+S_t - S^{fix})\;\frac{\hat{d}_t^f}{\hat{\phi}_t}) \qquad (14)$$

2.3 The monetary authorities

2.3.1 Fixed exchange rate regime

We assume that, prior to period t, the monetary authorities have been maintaining a fixed exchange rate regime. We assume that this policy was implemented to abandon the so-called 'inflationary bias', caused by the policymakers' incentive to stimulate output above its natural level.[22] The monetary authorities guarantee the fixed level of the exchange rate by standing ready to buy or sell domestic currency in return for foreign currency at the fixed rate. This implies that any change in the nominal interest rate - needed to maintain the equality in (4), given the fixed exchange rate - is automatically facilitated by an adjustment of the money supply. If, for example, the foreign interest rate rises, market participants will want to sell domestic debt titles, exchange the receipts for foreign currency and buy foreign debt titles. Under a floating exchange rate, this selling of domestic currency would cause it to depreciate. In case of a fixed exchange rate, the monetary authorities will accommodate this selling at the fixed rate. As a consequence, its stock of foreign reserves will fall and the domestic money supply will fall. The resulting higher domestic interest rate will restore the equilibrium in (4). In our model, the foreign interest rate is assumed fixed and the maintenance of a fixed exchange rate is limited to simply keeping the real money supply constant. However, the policy implications are not much different. Monetary policy is no longer a policy instrument as it cannot be used to stimulate output.

However, the fixed exchange rate regime is not irreversible. We assume that, as in second-generation models of currency crises, the maintenance of a fixed exchange rate is a matter of trade-off. As long as the costs of maintenance do not exceed the costs of abandonment of this regime, the authorities choose to maintain the fixed level. If this is no longer the case, they will abandon the peg and allow the exchange rate to float. The costs of maintenance and abandonment are dependent on the monetary authorities' preferences, discussed in the next subsection.

2.3.2 Preferences

We assume the monetary authorities to care about both the level of inflation and the level of output. Its preferences are given by the following loss function, which is assumed to reflect society's losses. Consequently, the monetary authorities simply maximise social welfare.

[22] The monetary authorities' preferences are discussed in the next subsection.

$$L_t^{CB} = \frac{\chi}{\eta}\, \dot{p}_{t+1}^2 + (y_t - y_n - k)^2 \qquad (15)$$

All variables in logarithms, except for χ and η;
χ, η and k assumed to be strictly positive

- χ relative weight put on price stabilisation (degree of conservativeness of the monetary authorities)
- η (1+n), where n denotes the monetary authorities' rate of time preference
- k positive wedge between the output level targeted by the monetary authorities and the natural output level

Equation (15) contains two types of costs. The first part of the right-hand side of equation (15) denotes the cost of a non-zero rate of inflation. Since our two-period model assumes price stickiness in the short-run, inflation can only be non-zero in period t+1. Given rational expectations and long-run equilibrium debt levels in period t+1, market participants anticipate the t+1 level of inflation. Moosa (1997) mentions 4 types of costs that are associated with anticipated inflation: '(1) "shoe-leather" costs arising from trying to economise on real money balances; (2) the "menu" costs arising from the recurrent revision of price lists and labels; (3) the costs associated with the operation of a less-than-perfectly-indexed tax system; and (4) the adverse effect on the balance of payments arising from the loss of competitiveness[23].' In addition to these specific cost types, a more general argument that is sometimes made is that higher levels of inflation are associated with higher variability of inflation rates.[24] Assuming that variability of inflation is undesirable from a society's point of view, this could also make an argument for reducing the level of inflation.

The second part illustrates the cost of a deviation of output from the monetary authorities' optimal level, $y_n + k$. As the monetary authorities can only influence the level of output in the short-run, the costs of output deviations in the long run, when output equals its natural level, are taken as given. Possible rationales for the positive wedge between the targeted output level and the natural output level could be related to the political business cycle or an imperfectly functioning labour market. The latter could, according to Obstfeld and Rogoff (1996), even from a social welfare point of view[25], cause an incentive to stimulate output above its natural level. For example, the existence of distortions like a minimum wage level and/or an income tax may cause the socially optimal level of unemployment to be below the natural level. Alternatively, wage negotiatiors may only be concerned with the welfare of the employed people and may disregard the interests of the unemployed, leading to a wage level that exceeds the socially optimal level.

[23] This last element is of less importance in the context of our model since we assume purchasing power parity in period t+1.

[24] Refer to for example Eijffinger and De Haan (1996), Friedman (1977) and Chowdhury (1991).

[25] Recall that we assume the monetary authorities to maximise social welfare.

The trade-off between costs of maintenance and costs of abandonment, explained in terms of output and inflation deviations, closely relates to the literature on rules and discretion in monetary policy.[26] In particular, the 'temptation' to stimulate output above its natural level versus the 'enforcement' of higher inflation in the future was first introduced by Barro and Gordon (1983). In an earlier paper, Kydland and Prescott (1977) argued in favor of formal monetary policy rules to limit the inflationary bias resulting from discretionary policy. If, for example, the policymakers announce a credible zero inflation rule and, consequently, inflation expectations are brought down to zero, they will ex post have an incentive[27] to generate a positive rate of inflation. However, in a model with rational expectations, market participants will anticipate this 'cheating behavior' of the policymakers and will adjust their expectations accordingly. Barro and Gordon (1983) extend the analysis to a multiperiod model in which the loss of reputation can substitute for formal rules. If the monetary authorities do not stick to the rule in the current period, they will face a higher level of inflation in the subsequent periods. The latter effect is defined as the 'enforcement', as it creates an incentive for the policymakers to obey the rule.

2.3.3 Post-collapse monetary policy

We assume that, in order to bring inflationary expectations down in one period, the monetary authorities have to announce the peg one period earlier. Moreover, we assume that monetary policy can be adjusted only once per period. Consequently, if the monetary authorities decide to abandon the peg in period t, they cannot credibly install a new peg throughout the remainder of period t and period t+1. The only alternative left is to run a fully flexible exchange rate regime.[28] Monetary policy is now no longer restricted by an exchange rate target and can be set freely. As a consequence, the monetary authorities will set monetary policy so as to minimise their loss each period.

3 Solving the model

In order to solve the model, it is useful to start by deriving the discretionary long-run equilibrium. This is the equilibrium in the absence of a fixed exchange rate regime or any alternative monetary policy rule and with debt ratios at their natural levels.

3.1 Discretionary equilibrium

As explained before, we assume policymakers and market participants to have perfect foresight, given that domestic and foreign debt ratios are at their natural

[26] For an overview, please refer to Sijben (1996)

[27] Barro and Gordon (1983) refer to this incentive as 'temptation'.

[28] As stated before, we abstract from any less extreme forms of limitations of exchange rate variability, like for example exchange rate bands.

levels[29]. This implies that market participants will anticipate monetary policy and the price level will be set so as to ensure that output does not deviate from its natural level. However, since the targeted level exceeds the natural output level, the monetary authorities face an incentive to stimulate output above its natural level. Market participants foresee this and therefore adjust their inflation expectations, which will be reflected in the period t price level. The resulting positive level of inflation, that arises without any output gain, is called the 'inflationary bias'. It results from the incentive to cheat and the absence of any enforcement mechanism[30]. We define this inflationary bias as π^n, which could be understood as 'the natural rate of inflation' under rational expectations.

Appendix A shows the derivation of the discretionary equilibrium. The optimal level of the money supply is shown to be:

$$\begin{aligned} M_t &= M_{t-1} + \frac{X}{\frac{\chi}{\eta}} \cdot k \qquad (16) \\ where\ X &= (\lambda + \theta) \left(\frac{1+\beta}{\beta} \right) \end{aligned}$$

with the inflationary bias being:

$$\pi^n = \frac{X}{\left(\frac{\chi}{\eta}\right)} \cdot k \qquad (17)$$

The determinants of the inflationary bias are rather straightforward. It is positively depending on λ and θ because these coefficients imply the effectiveness of activist monetary policy through the 'interest rate' and 'exchange rate' channels, respectively. Higher levels of effectiveness correspond to a more activist monetary policy. Further, the inflationary bias is negatively depending on β, which indicates the inverse of the impact of money supply changes on the level of the interest rate.[31] Higher levels of β correspond to a lower impact of monetary easening on the interest rate and reduce the monetary authorities' incentive to cheat. The inflationary bias also decreases with the monetary authorities' degree of conservativeness, $\frac{\chi}{\eta}$, as inflation gets more costly. Finally, the positive wedge between the output level targeted by the monetary authorities' and the natural output level, k, causing the inflationary bias in the first place, has a positive effect on its size.

3.2 Equilibria under an initially fixed exchange rate

Now that we have determined the 'natural level of inflation', we proceed by deriving the equilibria under maintenance and abandonment of the fixed exchange

[29] Since we are solving the discretionary long-run equilibrium, by assumption the debt ratios do not deviate from their natural levels.

[30] like the earlier mentioned formal rules (Kydland and Prescott (1977)) or loss of reputation (Barro and Gordon (1983)).

[31] Recall equation (1)

rate regime. Therefore, we assume a fixed exchange rate regime to be in place, prior to period t. Note that we still assume the economy to be in long-run equilibrium in period t-1 and t+1. However, in period t, the economy may temporarily depart from long-run equilibrium, as the domestic and foreign debt ratios may deviate from their natural levels. We will determine the conditions under which it becomes too costly for the monetary authorities to maintain the currency peg, and, in particular, how the sizes of the debt ratios relate to this possible abandonment.

3.2.1 Maintenance of the fixed exchange rate

Appendix B(1) shows the derivation of the equilibrium in case of maintenance of the fixed exchange rate throughout period t. The costs of maintenance are shown to be equal to:

$$L_t^{CB} = \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t} \right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \right) \; + \; k \right)^2 \tag{18}$$

If debt levels equal their natural levels, the costs of maintenance simply equal k^2. Equation (18) shows how deviations of the domestic and foreign debt levels increase the costs of maintaining a fixed exchange rate. Intuitively, the higher debt levels correspond to higher risk premiums on domestic debt titles. For any given level of the money supply, the domestic real interest rate increases and as a consequence, output will fall below its natural level, increasing the output costs of maintenance.

3.2.2 Abandonment of the fixed exchange rate

Appendix B(2) shows the derivation of the equilibrium in case of abandonment of the fixed exchange rate in period t. The costs of abandonment are shown to be equal to:

$$\begin{aligned} L_t^{CB} &= \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta} + A^2} \left(A \cdot \pi^n + \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \right) + k \right) \right)^2 \\ where\ A &= \frac{(1+\beta)}{\beta} \left(\frac{\lambda \left(1 - \frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} + \theta \right) \end{aligned} \tag{19}$$

3.2.3 Maintenance or Collapse?

Equation (18) and (19) showed the costs of maintenance and abandonment of a fixed exchange rate regime, respectively. As long as the costs of maintenance do not exceed the costs of abandonment, the fixed exchange rate regime will survive. However, as soon as the costs of maintenance do exceed the costs of abandonment, the monetary authorities will choose to abandon the peg and install a floating exchange rate. Appendix B(3) shows that this will be the case if:

$$\Omega = \left(\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} - \frac{1}{A}\right)\left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right) - \pi^n > 0 \tag{20}$$

The function Ω contains several variables that, together, determine whether the fixed exchange rate will survive. The separate effect of every variable on the probability of crisis can be determined by using first-order derivatives.[32] Section 4 will discuss the alternative determinants of currency crises. Note that a positive first-order derivative does not necessarily correspond to a higher probability of collapse, as it may be the case that the maximum value of the first part of the righthand side of equation (20), $\left(\sqrt{\frac{1}{A^2} + \frac{1}{\frac{\chi}{\eta}}} - \frac{1}{A}\right)\left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right)$, will under no circumstances exceed the natural level of inflation, π^n. However, this would imply that the costs of future inflation always exceed the costs of lower output in the short run, regardless of the state of the economy. Given the severeness of economic downturn that is often observed in crisis countries, we do not find this implication intuitively appealing. We will therefore assume that output costs can, under specific circumstances, exceed the costs of future inflation.

4 Determinants of currency crises

We will now use the result in (20) to determine the effects of several model variables on the probability of a currency collapse. First and foremost, we want to show the influence of domestic and foreign currency denominated debt levels on the probability of collapse.

4.1 Domestic debt levels

The effect that the domestic debt level, $\frac{\hat{d}_t^d}{\hat{\phi}_t}$, has on the probability of collapse is given by the first-order derivative, as derived in Appendix B(4):

$$\frac{\partial\, \Omega}{\partial \left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} > 0 \tag{21}$$

[32] Note that we only consider the effect of a change in one variable on the function Ω. To determine the minimum absolute levels of individual variables at which a regime collapse takes place, one would have to use calibration in order to get meaningful numbers. We will leave this aside.

The positive sign of the first-order derivative implies that a higher level of domestic currency denominated debt will, ceteris paribus, increase the probability of a currency crisis. From Appendix B and equation (20) it can be shown that the positive effect of a higher domestic debt level on the probability of collapse consists of two components.

On the one hand, higher domestic debt levels raise the costs of maintenance due to the increase in the risk premium that borrowers have to pay. The level of investment will fall and consequently, output will fall further below the targeted level. This output cost can be compensated for by abandoning the fixed exchange rate and lowering the real interest rate. In equation (20), this component is reflected in the second part (between brackets) of the righthand side, $\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)$. We will refer to this component as the **'need for stabilisation'**. Higher output costs of maintenance make it more urgent for the monetary authorities to compensate for this output loss.

On the other hand, higher domestic debt levels also influence the impact of a lower interest rate. Equation (86) in Appendix B(2) shows that the effectiveness of output loss compensation by monetary easening is positively depending on A. Since a higher level of domestic debt corresponds to a higher level of A, the effectiveness of abandoning the fixed exchange rate increases for higher domestic debt levels. In equation (20), the effectiveness of abandonment is reflected in the first part (between brackets) on the righthand side, $\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)$. Appendix B(4) shows that this part depends positively on A, reflecting the effectiveness argument above. Intuitively, a higher level of domestic debt makes an interest rate cut more effective, as it adds a larger decline of the risk premium to the initial cut. Consequently, the positive effect on output will be stronger. We will refer to this component as the **'effectiveness of abandonment'**.

Summarising, a higher level of domestic currency denominated debt will increase the probability of a currency crisis for two reasons. First, it increases the costs of maintenance, which creates a stronger incentive to compensate for the output loss. And second, it makes monetary easening more effective, creating a second incentive to abandon the currency peg.[33]

4.2 Foreign debt levels

Whereas the effect of higher domestic debt levels on the probability of currency crises is rather straightforward, the effect of higher foreign currency denominated debt levels is more complex. Appendix B(4) shows the first-order derivative:

[33] Although a higher level of domestic currency denominated debt makes monetary easening more effective, the effect on the level of the money supply cannot be determined without calibration. Recall equation (89) in Appendix B(2) and note that an increase in $\frac{\hat{d}_t^d}{\hat{\phi}_t}$ can both raise and lower the optimal level of the nominal money supply.

$$
\begin{aligned}
\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) \\
&\cdot\left(\lambda\ \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right) \\
&+\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\frac{\lambda}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \\
&\gtrless\ 0 \qquad (22)
\end{aligned}
$$

It can be shown that all righthand side terms in equation (22) have positive signs, except for the second, $\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)$. As a result, the sign of the effect of foreign debt on the probability of crisis equals the sum of a positive and negative term and is therefore, without further specification, indeterminable. However, again, a distinction can be made between the 'need for stabilisation' and the 'effectiveness of abandonment'. As in the case of higher domestic debt, the costs of maintenance increase, resulting in a stronger incentive to compensate for the output loss. This component refers to the part $\left(\lambda\ \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right)$ in equation (20). The effectiveness of monetary easening, however, decreases for higher levels of foreign debt, creating a reverse incentive. This follows from the first part of the righthand side of (20), $\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)$ and the negative relation between foreign debt and A. Intuitively, this reverse effect is explained as follows. Higher levels of foreign debt will, in case of monetary policy easening, partially cancel the interest rate decline. This is because the risk premium will, for higher foreign debt levels and ceteris paribus, increase in case of an abandonment of the fixed exchange rate. The higher risk premium occurs because the higher level of foreign debt will cause firms' net worth to drop, ceteris paribus, in case of a devaluation.

Summarising, the net effect of higher foreign currency denominated debt on the probability of a currency crisis equals the sum of two reverse components. On the one hand, it increases the costs of maintenance and consequently, the 'need for stabilisation'. On the other hand, it makes monetary easening less effective, creating an incentive to maintain the currency peg. Which component will dominate, depends on the values of the variables in our model.

4.3 Other variables

Appendix B(4) shows the effect of changes in the other model variables on the probability of crisis. The net effects of a higher level of conservativeness, time preference, and targeted output, are shown to contain two opposite effects. The impact of the real exchange rate and real interest rate elasticities of output, and the interest rate channel of monetary policy are also shown to be twofold. Consequently, the sign of the net effects of these variables cannot be determined without calibration. The effect of the natural domestic real interest rate on the probability of abandonment is positive as it lowers the firms' net worth and, consequently, raises the risk premium and the costs of maintenance. Finally, the impact of the interest rate elasticity of investment is shown to be negative because it lowers the net effect of an interest rate change on the level of the risk premium, and reduces the 'need for stabilisation' and the 'effectiveness of abandonment'. Please refer to Appendix B(4) for a more detailed explanation.

Refering to the effect of the monetary authorities' conservativeness, it may seem striking that the sign of this effect remains undeterminable. Note however, that we assume the institutional design of the monetary authorities to remain unchanged in case of abandonment of the fixed exchange rate regime. More conservative authorities will therefore lead to a lower post-collapse inflationary bias. One could argue that the design of the monetary authorities, and in particular the level of conservativeness, may change in case of abandonment of the fixed exchange rate. If the higher level of conservativeness, as mentioned before, only applies to the case of a fixed exchange rate, it will decrease the probability of collapse since the post-collapse inflationary bias does not change.

5 Conclusions

In this paper we have presented a two-period sticky-price monetary model to study a small open emerging-market economy. The monetary authorities have control over the level of the short-term exchange rate. Initially, they are assumed to run a fixed exchange rate regime to eliminate the inflationary bias that arises in the absence of any monetary policy rule. When deciding on whether to maintain this regime, they face a trade-off between output and inflation. The model shows how the levels of domestic currency denominated and foreign currency denominated short-term debt influence this trade-off. Through their impact on the risk premium that borrowers have to pay on their loans, the debt levels alter the level of the domestic real interest rate. Since output is in the short run assumed to depend on this interest rate, the levels of domestic and foreign debt affect short-run output and, consequently, the costs of maintenance and costs of abandonment of the fixed exchange rate. By deriving the discretionary equilibrium and the equilibria under maintenance and abandonment of the fixed exchange rate regime, the costs of maintenance and abandonment could be compared. More specifically, it enabled us to identify the condition under which the monetary authorities abandon the fixed exchange rate regime; an event that we, like in second-generation literature, refer to as a 'currency crisis'.

Given the condition for abandonment, the impact of several variables on the probability of crisis was measured by taking first-order derivatives. Although the actual occurrence of a crisis depends on the levels of a combination of variables, these derivatives indicate whether an increase in one variable brings the economy closer to or further away from crisis. When interpreting the impact of the variables, a distinction can be made between two components of the relative gains of abandonment. The first, which we referred to as the 'need for stabilisation', corresponds to the costs of maintenance. A higher level of these costs will, ceteris paribus, make the alternative of abandoning the fixed exchange rate relatively more attractive. The second component, referred to as 'the effectiveness of abandonment', corresponds to the degree to which abandoning the fixed exchange rate reduces the monetary authorities' loss. This component amounts to the impact of monetary easening on the level of output.

First and foremost, the impact of domestic and foreign currency denominated debt levels on the probability of crisis was discussed. It was shown that a higher level of domestic debt, ceteris paribus, increases the probability of collapse. On the one hand, higher domestic debt raises the costs of maintenance and, consequently, the 'need for stabilisation', due to the higher risk premium that borrowers have to pay. The level of investment will fall and, as a result, output will fall further below the targeted level. On the other hand, higher domestic debt levels also enlarge the impact of an interest rate cut and, thereby, the 'effectiveness of abandonment', as it adds a larger decline of the risk premium to the initial cut. Consequently, the positive effect on output will be stronger.

Whereas the effect of higher domestic debt levels on the probability of currency crises is rather straightforward, the effect of higher foreign debt is more complex. It was shown that the sign of this effect equals the sum of a positive and negative term. Again, a distinction can be made between the 'need for stabilisation' and the 'effectiveness of abandonment'. As in the case of domestic debt, the costs of maintenance increase due to a higher risk premium, resulting in a stronger incentive to stabilise output. The effectiveness of monetary easening, however, decreases because for higher foreign debt levels, a devaluation will cause a larger increase of the risk premium. This effect partially cancels the interest rate decline and, therefore, makes abandonment of the fixed exchange rate less effective.

In addition, the effects of several other variables on the probability of crisis were discussed. The net effects of a higher level of conservativeness, time preference, and targeted output, were shown to contain two opposite effects. Furthermore, it was pointed out that the impact of the real exchange rate and real interest rate elasticities of output, and the interest rate channel of monetary policy are also twofold. Finally, the effect of the natural domestic real interest rate was shown to be positive whereas the impact of the interest rate elasticity of investment was proven to be negative.

In this paper we have presented a model that combines the second-generation trade-off between costs of maintenance and abandonment with possible balance-sheet problems in the corporate sector. More in particular, we have shown how debt levels can move a small economy from a fixed exchange rate to a floating exchange rate equilibrium or vice versa, simply by altering the trade-off faced by the monetary authorities. Even if the monetary authorities still have a substantial amount of foreign reserves available to guarantee the fixed value of the currency, they might choose not to and abandon the fixed exchange rate regime.[34] As was mentioned in the introduction, it is often argued that first- and second-generation literature have not been able to explain the crisis in East Asia ('97-'98). The model presented in this paper, although not solely focusing on the Asian crisis, suggests otherwise. Adding the corporate balance sheet positions to second-generation models could substantially improve the explanatory power of these models in the Asian crisis case. In this respect[35], the high debt/equity ratios in the corporate sector of several Asian crisis countries at the time of crisis are remarkable. Especially when compared to the pre-crisis period in Mexico in 1994, when this country was facing interest rates as high as 75 % (annually) without collapsing, the Asian economies were more vulnerable because their corporations were much more highly leveraged. In South Korea for example, the debt/equity ratio in the corporate sector had been rising to 6.4 in 1996[36] - a number that seems hardly possible in western economies.

The analysis in this paper suggests that, in order to limit a country's vulnerability to crises, banks and firms should be less prone to changes in the interest rate and exchange rate. The former might for example be accomplished by further developing emerging equity markets.[37]

[34] Between March 1997 and June 1997 the level of international reserves in Thailand dropped by 5.7 billion US dollars. However, at the end of June it still amounted to 31.4 billions US dollars (Berg, 1999, Table 3. p.15). So when, on July 2 1997, the Bank of Thailand announced free-float of the previously basket-pegged baht, its stock of foreign reserves was nowhere near depletion.

[35] As already mentioned in the introduction.

[36] Berg (1999): Table 2, p.8.

[37] As discussed in IMF (2002).

Appendix A Discretionary long-run equilibrium

To derive the period t equilibrium, we have to consider period t-1[38], period t and period t+1.

Period t-1

Recalling equation (4), the domestic t-1 interest rate is given by:

$$i_{t-1} \ = \ i^{*} + \ S_t - \ S_{t-1} \ + \ RP_{t-1} \tag{23}$$

The foreign nominal interest rate equals c.[39] Given purchasing power parity in all periods and perfect foresight, $S_t - \ S_{t-1}$ equals π^n. Furthermore, since the domestic economy is in long-run equilibrium, the absolute domestic risk premium equals the absolute foreign risk premium (=0). Recalling (14), this implies that the domestic real interest rate and the debt ratios[40] equal their long-run equilibrium levels. As a consequence, $RP_{t-1} = 0$. Equation (23) can be rewritten as:

$$i_{t-1} \ = \ c + \pi^n \tag{24}$$

This yields the following money market equilibrium (equation (1)):

$$M_{t-1} \ - \ p_{t-1} \ = \ \gamma \ - \ \beta \ (c + \pi^n) \tag{25}$$

Period t

The price level in period t simply equals the sum of the t-1 price level and the natural inflation rate (since monetary policy in period t-1 supported the long-run equilibrium):

$$p_t = p_{t-1} + \pi^n \tag{26}$$

Money market equilibrium in period t is similar to equation (1)[41], with $RP_t = 0$.

$$M_t = p_t + \gamma - \beta \cdot i_t \tag{27}$$

Substituting (25) and (26) into (27) yields:

[38] Period t-1 is only considered here because in this period the expectations for period t are formed.

[39] equal to the sum of the foreign real interest rate (equation (3)) and the foreign level of inflation (assumed to be zero)

[40] Recall that the long-run equilibrium debt ratios are assumed to be zero.

[41] In equation (1) the price level was denoted as fixed. We assume, throughout this paper, that the price level cannot be adjusted throughout period t. However, the price level in equation (1) was assumed to be fixed as long as the fixed exchange rate regime was maintained. Here, monetary policy is discretionary and the price level changes every period.

$$M_t = M_{t-1} + \pi^n - \beta(i_t - c - \pi^n) \tag{28}$$

(28) shows how the existence of rational expectations influences the money market equilibrium. First of all, the nominal money supply in period t has to exceed the level in the previous period in order to keep up with the expected 'natural rate of inflation' (π^n). In addition, deviations of the money supply from its long-run equilibrium supporting value correspond to deviations of i_t from $c + \pi^n$ (the latter being the equilibrium value for i_t).

Period t+1

We assume that in period t+1 the economy is in long-run equilibrium:

$$M_{t+1} - p_{t+1} = \gamma - \beta\ (c + \pi^n) \tag{29}$$

Since the period t+1 price level is set to ensure that output will be at its natural level, it equals the sum of the price level that supports the equilibrium, given the period t money supply, and the natural rate of inflation.[42]

$$p_{t+1} = \pi^n + M_t - \gamma + \beta\ (c + \pi^n) \tag{30}$$

Equilibrium

Rewriting equation (27) yields the following expression for the period t price level.

$$p_t = M_t - \gamma + \beta \cdot i_t \tag{31}$$

For the level of inflation in period t+1 this implies:

$$p_{t+1} - p_t = \pi^n + \beta(c + \pi^n - i_t) \tag{32}$$

Rewriting equation (28) yields:

$$i_t = -\frac{(M_t - M_{t-1} - \pi^n)}{\beta} + c + \pi^n \tag{33}$$

Substituting (33) into (32) and rearranging:

$$p_{t+1} - p_t = M_t - M_{t-1} \tag{34}$$

Equation (34) defines the first part of the monetary authorities' loss function in terms of the money supply, M_t. Turning to the second part of the monetary authorities' loss function, the effect of monetary policy on output in period t runs through the real interest rate, r_t, and through the nominal exchange rate, S_t.

[42] or in other words, the price level equals the equilibrium level in case the money supply stays unchanged, plus the anticipated money supply change.

$$y_t \ = y_n \ - \ \lambda \ (r_t - r_n) \ + \ \theta \ (S_t \ - p_t) \tag{35}$$

We will first consider the 'interest rate channel'. Recall (33):

$$i_t = -\frac{(M_t - M_{t-1} - \pi^n)}{\beta} + c + \pi^n \tag{36}$$

Recall that, since we assume perfect foresight:

$$i_t = r_t + \dot{p}_{t+1} = r_t + M_t - M_{t-1} \tag{37}$$

Substituting (37) into (36) and rearranging yields:

$$r_t = -\frac{1+\beta}{\beta}(M_t - M_{t-1} - \pi^n) + c \tag{38}$$

Turning to the exchange rate effect of monetary policy on output in period t, $S_t \ - p_t$, recall equation (4):

$$i_t \ = \ i^* + \ (S_{t+1} - \ S_t) \ + \ RP_t \tag{39}$$

With $RP_t = 0$ and $i^* = c$, (39) can be rewritten as:

$$S_t = S_{t+1} - (i_t - c) \tag{40}$$

Recall that we assumed long-run equilibrium in period t+1, where purchasing power parity holds. Consequently, S_{t+1} equals p_{t+1}. Subtracting p_t yields:

$$S_t - p_t = p_{t+1} - p_t - (i_t - c) \tag{41}$$

Combining (33) and (34) yields:

$$\begin{aligned} S_t - p_t &= M_t - M_{t-1} - \left(-\frac{(M_t - M_{t-1} - \pi^n)}{\beta} + \pi^n \right) \\ &= \frac{1+\beta}{\beta}(M_t - M_{t-1} - \pi^n) \end{aligned} \tag{42}$$

We can now write the monetary authorities' loss function in terms of the nominal money supply and solve for the optimal level of the money supply.

Recall from (2) and (15) that:

$$L_t^{CB} \ = \frac{\chi}{\eta}\, \dot{p}_{t+1}^2 \ + \ (- \ \lambda \ (r_t - r_n) \ + \ \theta \ (S_t \ - p_t) - \ k)^2 \tag{43}$$

Substituting the results in (34), (38), and (42) into (43) yields:

$$\begin{aligned} L_t^{CB} &= \frac{\chi}{\eta}(M_t \ - \ M_{t-1})^2 \\ &+ \left(\ (\lambda + \theta) \left(\frac{1+\beta}{\beta} \right) (M_t - M_{t-1} - \pi^n) - k \right)^2 \end{aligned} \tag{44}$$

Minimisation of the monetary authorities' loss function yields the optimal level of the money supply:

$$\begin{aligned}\frac{\partial L_t^{CB}}{\partial M_t} &= 2\frac{\chi}{\eta}\left(M_t - M_{t-1}\right) \\ &\quad +2\left((\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)(M_t - M_{t-1} - \pi^n) - k\right)(\lambda+\theta)\left(\frac{1+\beta}{\beta}\right) \\ &= 0 \end{aligned} \tag{45}$$

$$\begin{aligned}\left(M_t - M_{t-1}\right)\left(\frac{\chi}{\eta} + \left((\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\right)^2\right) &= \pi^n\left((\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\right)^2 \\ &\quad + (\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\cdot k \\ &= 0 \end{aligned} \tag{46}$$

The resulting optimal level of the nominal money supply is:

$$\begin{aligned} M_t &= M_{t-1} + \frac{X^2}{\frac{\chi}{\eta} + X^2}\cdot \pi^n + \frac{X}{\frac{\chi}{\eta}+X^2}\cdot k \\ where\ X &= (\lambda+\theta)\left(\frac{1+\beta}{\beta}\right) \end{aligned} \tag{47}$$

The inflationary bias, π^n, can now be made explicit. We assumed perfect foresight, given that the debt levels are at their natural levels. This implies:

$$\pi^n = \dot{p}_{t+1}^e = \dot{p}_{t+1} = M_t - M_{t-1} \tag{48}$$

where $\dot{p}_{t+1}^e$ is the expected level of inflation in period t+1 ($= p_{t+1}^e - p_t$). Substituting (48) into (47) and solving for M_t yields:

$$M_t = M_{t-1} + \frac{X}{\frac{\chi}{\eta}}\cdot k \tag{49}$$

(48) and (49) imply the following for the inflationary bias:

$$\pi^n = \frac{X}{\left(\frac{\chi}{\eta}\right)}\cdot k \tag{50}$$

Appendix B Equilibria under an initially fixed exchange rate

B1 Maintenance of the fixed exchange rate

Again, we consider the equilibria in period t-1, t, and t+1, but now under the condition that the monetary authorities decide to maintain the fixed exchange rate regime throughout period t.

Period t-1

Assuming long-run equilibrium, the risk premium is assumed to be zero ($RP_{t-1} = 0$). Furthermore, since the monetary authorities maintain the peg, the exchange rate will remain constant. Consequently, equation (4) can be reduced to:

$$i_{t-1} \;=\; c \tag{51}$$

For the money market equilibrium[43] this implies the following:

$$M_{t-1} \;-\; \bar{p}_{t-1} \;=\; \gamma \;-\; \beta \cdot c \tag{52}$$

Period t

Assuming a fixed exchange rate and allowing for deviations of debt levels, equation (4) can be reduced to:

$$i_t \;=\; c + RP_t \tag{53}$$

Money market equilibrium now implies:

$$M_t \;=\; \bar{p}_t + \gamma \;-\; \beta \cdot c \tag{54}$$

and, since the price level has not changed:

$$M_t = M_{t-1} \tag{55}$$

Period t+1

Under the assumptions that the fixed exchange rate is maintained throughout period t and the debt levels return to their natural levels, the equilibrium in period t is similar to the period t-1 equilibrium:

$$i_{t+1} \;=\; c \tag{56}$$

Since the price level has not changed, money market equilibrium is identical to period t-1:

[43] Recall equation (1)

$$M_{t+1} - \bar{p}_{t+1} = \gamma - \beta \cdot c \tag{57}$$

Equilibrium

Since we have assumed that the monetary authorities maintain the currency peg[44], we can calculate the costs of maintenance, according to the monetary authorities ' loss function:

$$L_t^{CB} = \frac{\chi}{\eta} \dot{p}_{t+1}^2 + (- \lambda (r_t - r_n) + \theta (S_t - p_t) - k)^2 \tag{58}$$

As shown above, the price level remains fixed. Consequently, period t+1 inflation equals zero. Moreover, the level of the exchange rate also remains fixed. Given the assumption of purchasing power parity in period t-1, this implies that the period t price level equals the period t level of the exchange rate. Equation (58) can therefore be reduced to:

$$L_t^{CB} = (- \lambda (r_t - r_n) - k)^2 \tag{59}$$

Since inflation is zero, the domestic real interest rate equals the domestic nominal interest rate.

$$r_t = i_t = c + RP_t \tag{60}$$

Substituting (14) into (60) yields:

$$r_t = c - \delta (r_t - r_n) + (1 + r_t) \frac{\hat{d}_t^d}{\hat{\phi}_t} + (1 + S_t - S^{fix}) \frac{\hat{d}_t^f}{\hat{\phi}_t}) \tag{61}$$

For $S_t - S^{fix} = 0$, rearranging yields:

$$r_t = \frac{(1 + \delta) \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t} \right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} \tag{62}$$

For the costs of maintenance (59) this implies:

$$L_t^{CB} = \left(\lambda \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t} \cdot c + \left(\frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t} \right)}{\left(1 + \delta - \frac{\hat{d}_t^d}{\hat{\phi}_t} \right)} \right) + k \right)^2 \tag{63}$$

[44] Ex post, we will define the conditions under which the monetary authorities will choose to maintain the fixed exchange rate. These conditions depend on the trade-off between the costs of maintenance and abandonment.

B2 Abandonment of the fixed exchange rate

Period t-1

Assuming a fixed exchange rate prior to period t, the period t-1 equilibrium in the 'abandonment' scenario is similar to the t-1 equilibrium in case of maintenance:

$$i_{t-1} \;=\; c \tag{64}$$

$$M_{t-1} \;-\; \bar{p}_{t-1} \;=\; \gamma \;-\; \beta \cdot c \tag{65}$$

Period t

We assume the monetary authorities to abandon the peg in period t. As a result, they regain their monetary policy autonomy and will set the money supply so as to minimise its loss function. Given the possible deviation of debt levels in period t, money market equilibrium denotes the following:

$$M_t \;-\; \bar{p}_t \;=\; \gamma \;-\; \beta(i_t - RP_t) \tag{66}$$

Given that $\bar{p}_t = \bar{p}_{t-1}$, (66) can be rewritten as:

$$(i_t - RP_t) = -\frac{(M_t \;-\; \bar{p}_t - \gamma)}{\beta} = -\frac{(M_t - M_{t-1})}{\beta} + c \tag{67}$$

Recall equation (4) for the revised uncovered interest parity condition:

$$i_t \;=\; i^* + \;\; (S_{t+1} - \;S_t) \;\; + \;\; RP_t \tag{68}$$

Period t+1

We assume that, given the abandonment of the fixed exchange rate in period t, the economy will adjust to its new long-run equilibrium in period t+1. Therefore, the t+1 price level equals the equilibrium level in case the money supply stays at its period t level, plus the anticipated money supply change[45].

$$p_{t+1} = \pi^n + M_t - \gamma + \beta \; (c + \pi^n) \tag{69}$$

Further, the money market equilibrium and uncovered interest parity equations are given by:

$$M_{t+1} \;-\; p_{t+1} \;=\; \gamma \;-\; \beta(c + \pi^n) \tag{70}$$

$$i_{t+1} \;=\; c + \pi^n \tag{71}$$

[45] Recall that this anticipated change simply equals the level of the inflationary bias, as derived in Appendix A.

Equilibrium

Given the equilibria above, we calculate the costs of abandonment, according to the familiar loss function:

$$L_t^{CB} = \frac{\chi}{\eta}\, \dot{p}_{t+1}^2 \;+\; (-\;\lambda\;(r_t - r_n) \;+\; \theta\;(S_t \;- p_t) -\; k)^2 \tag{72}$$

Starting with the level of inflation, combining (66) and (69) yields:

$$\begin{aligned} p_{t+1} - \bar{p}_t &= \pi^n + M_t - \gamma + \beta\;(c + \pi^n) - M_t \;+ \gamma \;-\; \beta(i_t - RP_t) \\ &= \pi^n - \beta(i_t - RP_t - (c + \pi^n)) \end{aligned} \tag{73}$$

Substituting (67) into (73) yields:

$$p_{t+1} - \bar{p}_t = (1 + \beta)\;\pi^n + M_t - M_{t-1} \tag{74}$$

Turning to the second part of the monetary authorities' loss function, the effect of monetary policy on output in period t runs through the real interest rate, r_t, and through the nominal exchange rate, S_t.

$$y_t \;= y_n \;-\; \lambda\;(r_t - r_n) \;+\; \theta\;(S_t \;- \bar{p}_t) \tag{75}$$

We will first consider the 'interest rate channel'. Recall (67):

$$i_t = -\frac{(M_t - M_{t-1})}{\beta} + c + RP_t \tag{76}$$

Equation (14) defined the risk premium:

$$RP_t \;=\; -\;\delta\,(r_t - r_n) \;+\; (1 + r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} \;+\; (1 + S_t - S^{fix})\;\frac{\hat{d}_t^f}{\hat{\phi}_t}) \tag{77}$$

The term $S_t - S^{fix}$ is not exogenous as it is depending on the interest rate. Rewriting equation (4) yields:

$$S_t = -(i_t - RP_t - i^*) + S_{t+1} \tag{78}$$

Given $i^* = c$ and $S_{t+1} = p_{t+1}$, and substituting (67), (78) can be written as:

$$S_t = \frac{(M_t - M_{t-1})}{\beta} + p_{t+1} \tag{79}$$

Recall that $S^{fix} = \bar{p}_t$; substituting (74) for the level of inflation yields:

$$S_t - S^{fix} = \frac{(M_t - M_{t-1})}{\beta} + p_{t+1} - \bar{p}_t = \frac{(1 + \beta)}{\beta}\;(M_t - M_{t-1} + \beta \cdot \pi^n) \tag{80}$$

Substituting (80) into (77) yields the following:

$$RP_t = -\ \delta\,(r_t - r_n)\ +\ (1+r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} + \left(1 + \frac{(1+\beta)}{\beta}\ (M_t - M_{t-1} + \beta\cdot\pi^n)\right)\ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \tag{81}$$

Substituting this result into (76):

$$i_t = -\frac{(M_t - M_{t-1})}{\beta} + c - \ \delta\,(r_t - r_n)\ +\ (1+r_t)\,\frac{\hat{d}_t^d}{\hat{\phi}_t} + \left(1 + \frac{(1+\beta)}{\beta}\ (M_t - M_{t-1} + \beta\cdot\pi^n)\right)\ \frac{\hat{d}_t^f}{\hat{\phi}_t}) \tag{82}$$

Recall that, once period t monetary policy is known, the t+1 level of inflation and, consequently, the period t real interest rate is also known.

$$i_t = r_t + \dot{p}_{t+1} = r_t + (1+\beta)\,\pi^n + (M_t - M_{t-1}) \tag{83}$$

Combining (82) and (83) and rearranging:

$$r_t = \frac{(1+\delta)\cdot c + \frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} - \frac{(1+\beta)}{\beta}\frac{\left(1 - \frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\,(M_t - M_{t-1} + \beta\cdot\pi^n) \tag{84}$$

Turning to the exchange rate effect of monetary policy on output in period t, $S_t - p_t$ $(= S_t - S^{fix})$, recall equation (80):

$$S_t - p_t = \frac{(1+\beta)}{\beta}\ (M_t - M_{t-1} + \beta\cdot\pi^n) \tag{85}$$

Using (74), (84), and (85), we can now write the monetary authorities' loss function (72) in terms of the nominal money supply and solve for the optimal level.

$$L_t^{CB} = \frac{\chi}{\eta}\,((1+\beta)\,\pi^n + M_t - M_{t-1})^2 + \left(-\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d + \hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + A\,(M_t - M_{t-1} + \beta\cdot\pi^n) - k\right)^2 \tag{86}$$

$$where\ A = \frac{(1+\beta)}{\beta}\left(\frac{\lambda\left(1 - \frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta - \frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} + \theta\right)$$

Minimisation of the monetary authorities' loss function yields the optimal level of the money supply:

$$\begin{aligned}\frac{\partial L_t^{CB}}{\partial M_t} &= 2\frac{\chi}{\eta}\left(\left(1+\beta\right)\pi^n + M_t - M_{t-1}\right) \\ &\quad +2\left(-\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + A\left(M_t - M_{t-1} + \beta\cdot\pi^n\right) - k\right)\cdot A \\ &= 0 \end{aligned} \tag{87}$$

$$\begin{aligned}\left(\frac{\chi}{\eta}+A^2\right)\left(M_t - M_{t-1}\right) &= -\frac{\chi}{\eta}\left(1+\beta\right)\pi^n - A^2\cdot\beta\cdot\pi^n \\ &\quad +A\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\end{aligned} \tag{88}$$

$$M_t = M_{t-1} - \left(\beta + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{A}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right) \tag{89}$$

Substituting the optimal money supply into (86) yields:

$$\begin{aligned}L_t^{CB} &= \frac{\chi}{\eta}\left(\left(\frac{A^2}{\frac{\chi}{\eta}+A^2}\right)\cdot\pi^n + \frac{A}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \\ &\quad + \left(-\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n - \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2\end{aligned} \tag{90}$$

Rearranging yields:

$$\begin{aligned}L_t^{CB} = &\quad \frac{A^2}{\frac{\chi}{\eta}}\left(\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \\ &\quad + \left(\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2\end{aligned} \tag{91}$$

or shorter:

$$L_t^{CB} = \left(\frac{A^2}{\frac{\chi}{\eta}} + 1\right)\left(\left(\frac{\frac{\chi}{\eta}\cdot A}{\frac{\chi}{\eta}+A^2}\right)\pi^n + \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \tag{92}$$

Finally, (92) can be further simplified to:

$$L_t^{CB} = \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(A\cdot\pi^n + \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2 \tag{93}$$

B3 Maintenance or Collapse?

The monetary authorities will abandon the fixed exchange rate regime if the costs of maintenance exceed the costs of abandonment. Recalling equation (18) and (19), this implies:

$$\begin{aligned}&\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right)^2 \\ > \; & \frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}\left(A\cdot\pi^n + \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)^2\end{aligned} \tag{94}$$

rewriting:

$$\begin{aligned}&\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right) \\ > \; & \sqrt{\frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}}\left(A\cdot\pi^n + \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\right)\end{aligned} \tag{95}$$

rewriting:

$$\left(1-\sqrt{\frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c + \left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) + k\right) > \sqrt{\frac{\frac{\chi}{\eta}}{\frac{\chi}{\eta}+A^2}}\cdot A\cdot\pi^n \tag{96}$$

$$\left(\sqrt{\frac{\frac{\chi}{\eta}+A^2}{\frac{\chi}{\eta}}}-1\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)>A\cdot\pi^n \tag{97}$$

$$\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)-\pi^n>0 \tag{98}$$

$$\text{where } A=\frac{(1+\beta)}{\beta}\left(\frac{\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}+\theta\right)$$

For simplicity, we will define the lefthand side of (98) as follows:

$$\Omega=\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)-\pi^n \tag{99}$$

B4 Crisis determinants

Domestic debt level

The first-order derivative of Ω in terms of the domestic debt level is given by:

$$\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}=\frac{\partial\left(\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)-\pi^n\right)}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \tag{100}$$

Using the product rule, (100) can be rewritten as:

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} &= f'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)\cdot g\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)\\ &\quad+f\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)\cdot g'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)-\frac{\partial\pi^n}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \qquad (101)\\ \text{where } f\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) &= \left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\\ \text{and } g\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) &= \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\end{aligned}$$

Since the inflationary bias is not depending on the debt levels, the last part of the righthand side of (101) is equal to zero. Furthermore, $f'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)$ and $g'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)$ are given by:

$$
\begin{aligned}
f'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) &= \frac{\partial\, f\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}{\partial A} \cdot \frac{\partial A}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \\
&= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}} \cdot A^3} + \frac{1}{A^2}\right) \cdot \left(\frac{(1+\beta)\ \lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\beta\ \left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2}\right) \qquad (102)
\end{aligned}
$$

$$
g'\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right) = \frac{\lambda\left((1+\delta)\,(1+c)+\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2} \qquad (103)
$$

Substituting (102) and (103) into (101) yields:

$$
\begin{aligned}
\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}} \cdot A^3} + \frac{1}{A^2}\right) \cdot \left(\frac{(1+\beta)\ \lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\beta\ \left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2}\right) \\
&\quad \cdot \left(\lambda\ \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right) \\
&\quad + \left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right) \cdot \frac{\lambda\left((1+\delta)\,(1+c)+\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2} \qquad (104)
\end{aligned}
$$

Given the specified ranges of possible values for the variables and coefficients, all righthand side parts are strictly positive. Consequently:

$$
\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} > 0 \qquad (105)
$$

Foreign debt level

The first-order derivative of Ω in terms of the foreign debt level is given by:

$$
\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} = \frac{\partial\left(\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\lambda\ \left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right)\ -\ \pi^n\right)}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} \qquad (106)
$$

Using the product rule, (106) can be rewritten as:

$$\begin{aligned}
\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} &= F'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)\cdot G\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) \\
&\quad +F\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)\cdot G'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)-\frac{\partial\pi^n}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} \qquad (107)\\
\textit{where } F\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) &= \left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\\
\textit{and } G\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) &= \left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right)
\end{aligned}$$

Since the inflationary bias is not depending on the debt levels, the last part of the righthand side of (107) is equal to zero. Furthermore, $F'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)$ and $G'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)$ are given by:

$$\begin{aligned}
F'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right) &= \frac{\partial\ f\ \left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\partial A}\cdot\frac{\partial A}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}\\
&= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) \qquad (108)
\end{aligned}$$

$$G'\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)=\frac{\lambda}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)} \qquad (109)$$

Substituting (108) and (109) into (107) yields:

$$\begin{aligned}
\frac{\partial\,\Omega}{\partial\left(\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(-\frac{(1+\beta)\ \lambda}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\\
&\quad\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)\ +\ k\right)\\
&\quad+\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\frac{\lambda}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\gtrless 0 \qquad (110)
\end{aligned}$$

Other variables

Conservativeness and time preference We determine the impact of the monetary authorities' degree of conservativeness, χ, and rate of time preference, η, as follows:

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\left(\frac{\chi}{\eta}\right)} &= -\frac{1}{2\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}}\cdot\frac{1}{\left(\frac{\chi}{\eta}\right)^2}\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\\ &\quad+(\lambda+\theta)\left(\frac{1+\beta}{\beta}\right)\frac{k}{\left(\frac{\chi}{\eta}\right)^2}\\ &\gtrless 0 \end{aligned} \tag{111}$$

(111) shows that the effect of conservativeness on the probability of crisis is the sum of two reverse components. On the one hand, more conservative authorities lower the inflationary bias, which diminishes the enforcement of a fixed exchange rate and increases the probability of crisis. On the other hand, it increases the costs of abandoning the peg because inflation is more costly. The latter reduces the probability of abandonment.

A higher rate of time preference increases the inflationary bias and lowers the costs of abandonment because the present value of the future inflation costs decrease.

Wedge between targeted output and natural output The impact of a higher level of targeted output (relative to natural output) on the probability of crisis is given by the following first-order derivative:

$$\frac{\partial\,\Omega}{\partial k}=\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\lambda-\frac{(\lambda+\theta)}{\left(\frac{\chi}{\eta}\right)}\left(\frac{1+\beta}{\beta}\right)\gtrless 0 \tag{112}$$

The impact on the probability of crisis is also twofold. It increases the inflationary bias but, at the same time, increases the costs of maintenance and, therefore, the 'need for stabilisation', as defined in section 4.1.

The natural domestic real interest rate The effect of the natural domestic real interest rate, equal to c, is given by:

$$\frac{\partial\,\Omega}{\partial c}=\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\cdot\left(\lambda\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)>0 \tag{113}$$

In our model, a higher level of the natural domestic real interest rate will lower firms' net worth for every level of debt. This implies a higher risk premium and, consequently, higher costs of maintenance and a higher 'need for stabilisation'.

The interest rate elasticity of investment The effect of δ on the probability of crisis is given by:

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\delta} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\left(-\frac{(1+\beta)\,\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\beta\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2}\right)\\ &\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\\ &-\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)^2}\right)\\ &< 0 \end{aligned} \tag{114}$$

The first-order derivative is strictly negative. The intuitive explanation follows from equation (14). Note that a higher δ implies that the net worth decline in case of an interest rate increase will to a larger degree be compensated by lower investments. As a result, the net effect of an interest rate change on the risk premium will be smaller. For the trade-off between costs of maintenance and abandonment this means that both the 'need for stabilisation' and the 'effectiveness of abandonment' will decrease. The need for a lower interest rate is smaller because the risk premium is lower for higher values of δ. The effectiveness of abandoning the fixed exchange rate is lower because monetary easening will have a smaller net effect on the risk premium.

The real exchange rate elasticity of output The impact of θ on the probability of abandonment is given by the following first-order derivative:

$$\begin{aligned}\frac{\partial\,\Omega}{\partial\theta} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(\frac{1+\beta}{\beta}\right)\\ &\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)\\ &-\left(\frac{1+\beta}{\beta}\right)\frac{k}{\left(\frac{\chi}{\eta}\right)}\\ &\gtrless 0 \end{aligned} \tag{115}$$

As was the case with several variables discussed above, the impact of the real exchange rate elasticity of output is twofold. The 'effectiveness of abandonment' increases because a devaluation will have a larger positive impact on output. However, the inflationary bias also increases because the monetary authorities face a larger incentive to ease their monetary policy stance.

The domestic real interest rate elasticity of output Recall that the domestic real interest rate elasticity of output, λ, is strongly related to the earlier discussed interest rate elasticity of investment, δ, although this relation is not made explicit in our paper.[46] The first-order derivative of Ω can be shown to be the following:

$$\begin{aligned} \frac{\partial \Omega}{\partial \lambda} &= \left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\frac{(1+\beta)}{\beta}\left(\frac{\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right) \\ &\quad \cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right) \\ &\quad +\left(\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}-\frac{1}{A}\right)\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}+k\right) \\ &\quad -\left(\frac{1+\beta}{\beta}\right)\frac{k}{\left(\frac{\chi}{\eta}\right)} \\ &\gtrless 0 \end{aligned} \tag{116}$$

The impact of λ is comparable to the impact of θ. It also increases the 'effectiveness of abandonment' and the inflationary bias. Additionally, however, it also increases the costs of maintenance and, consequently, the 'need for stabilisation'. The sign of the net effect is, again, indeterminable without calibration.

The 'interest rate channel of monetary policy' coefficient The impact of monetary policy on the interest rate is given by the coefficient β. Higher levels of β correspond to a smaller impact of monetary policy on the interest rate. The first-derivative of Ω is given by:

[46] This relation depends on the degree to which total output is made up of investment.

$$
\begin{aligned}
\frac{\partial\,\Omega}{\partial\beta} &= -\left(-\frac{1}{\sqrt{\frac{1}{A^2}+\frac{1}{\frac{\chi}{\eta}}}\cdot A^3}+\frac{1}{A^2}\right)\cdot\left(\frac{\lambda\left(1-\frac{\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}+\theta\right)\cdot\frac{1}{\beta^2} \\
&\quad\cdot\left(\lambda\left(\frac{\frac{\hat{d}_t^d}{\hat{\phi}_t}\cdot c+\left(\frac{\hat{d}_t^d+\hat{d}_t^f}{\hat{\phi}_t}\right)}{\left(1+\delta-\frac{\hat{d}_t^d}{\hat{\phi}_t}\right)}\right)+k\right)+\left((\lambda+\theta)\frac{k}{\left(\frac{\chi}{\eta}\right)}\right)\frac{1}{\beta^2} \\
&\gtrless 0
\end{aligned}
\tag{117}
$$

A higher level of β decreases the 'effectiveness of abandonment' because monetary easening has a weaker effect on the interest rate. On the other hand, it lowers the inflationary bias for the same reason. The net effect is, as before, undeterminable.

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