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Abstract

In economic discussions, currency board systems are frequently described as arrangements with self-binding character to the monetary authorities by their strict rules and establishments by law. Hard pegs and especially currency boards are often seen as remedies to overcome economic and financial turmoils and to return to low inflation. A sustainable debt level closely linked to a disciplined fiscal policy is, however, a premise for medium-term success. We show in a two-period model that the choice of a currency board can increase fiscal discipline compared to a standard peg regime. We derive, furthermore, the conditions for a currency boards to gain a stability advantage compared to a common peg system.

JEL-classification: E52, E58, E62, F33
Keywords: currency board, fixed exchange rate, commitment, inflation bias, fiscal discipline, public debt, time-inconsistency problem

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1 Introduction

The experience on currency board systems since the 1990s has shown that this special form of an exchange rate system can contribute to overcome eras of financial turmoil and can help to stabilize the economy after currency crises (Argentina, Bulgaria). Furthermore, countries without great experience in central banking – like e.g. the former Soviet republics Estonia and Lithuania – achieved high credibility of their currencies, which is reflected by a process of pinning down inflation from three digit levels to single digit rates within a short period of time after introducing a currency board system. Recent experience also leads to the presumption that a currency board is less crisis prone compared to a standard fixed exchange rate system.

The gain in credibility and stability may be traced back to the high discipline of monetary policy accompanied by the choice of a currency board system: It is established by law and characterized by an absolute fixed exchange rate to an anchor currency, full coverage of the monetary base, and full convertibility. These features altogether imply a strict rule of monetary policy by abstaining from an independent monetary policy. Calvo (2000) strengthens that view by suggesting that in emerging markets when sudden stops are possible, the emphasis should be on credibility, "where the central banker may have to tie himself to the mast or a currency board to command any respect" (p.4).

Despite the successful reappearance of currency board regimes since the beginning of the 1990s, only view of researchers have addressed to model the differences between a currency board regime and a standard fixed exchange-rate systems: Chang and Velasco (2000), Oliva et al. (2001), Irwin (2004) and Feuerstein and Grimm (2006).

All these papers have in common that the effects of fiscal policy and the role of public debts are neglected or are captured by realizations of stochastic shocks. However, although hardly analyzed in theoretical literature, the economic performance of currency board countries, especially those in Europe and Hong-Kong, but also Argentina during the period of 1991 to 1995, was good and accompanied by a sound fiscal policy and a sustainable development of public debts. This has also been subject to many econometric studies, like for example Ghosh et al. (2000), Fatas and Rose (2001), Sun (2003) and Grigonyte (2003) to mention only a few of them.

In this paper, the focus will be laid on the stability and credibility of currency board systems by additionally taking fiscal policy into account. The central questions of our analysis are (i) whether and under what circumstances a currency board guarantees more fiscal discipline and a more sustainable growth of debts compared to a standard peg, and (ii) which factors contribute to higher or less stability of a currency board system.

The paper is structured as follows. First, related empirical literature and the few existing theoretical papers on that topic are summarized. Second, we develop a two-period macroeconomic model, which integrates fiscal policy and public debts. Third, we use the model framework and show that optimal debt levels and the optimal amount of government expenditure are lower under a currency board compared to a standard fixed exchange-rate regime, when assuming at the same time that both exchange rate systems are maintained.[1] Hence, we state that a currency board increases the discipline

[1]Maintaining the standard fixed exchange-rate system means in this context that the exchange rate

of fiscal policy. Fourth, we examine the stability of a currency board system by using two numerical scenarios. We define the stability of a currency board as the difference between the expected policy losses occurring in the cases that the currency board is maintained and that it is abandoned. Then, we examine which factors drive the stability of a currency board system and which factors contribute to less stability. Fifth, we finish our theoretical analysis by comparing a currency board system and a standard peg regime. In this context, we use the concept of the "credibility of an exchange rate system" which denotes the probability that the current exchange rate system is maintained in the next period. We derive the conditions under which a currency board gains a higher credibility compared to a standard peg and vice versa. Sixth, we conclude and highlight the main results of our analysis and give a brief outlook on further research.

2 Empirical and Theoretical Background

In the existing literature and in economic discussions, the effect of the introduction of a fixed exchange-rate regime on fiscal policy is discussed differently.

On the one hand, there is a broad view that fiscal policy is the only remaining stabilization instrument when large asymmetric shocks occur in a fixed exchange-rate regime. This may suggest that fiscal policy tends to be more expansionary in times of a recession under a peg regime compared to a flexible exchange-rate regime.

On the other hand, a country operating a fixed exchange-rate system aims at a gain in credibility and stability to achieve sustainable levels of the inflation rate and, thereby, to create a sound environment for economic growth. Unsound fiscal policy and high debts, however, can be interpreted by the private sector as an increasing risk of leaving the exchange rate peg in the future. As policy makers realize that a collapse of the exchange rate would induce high economic and political costs, they have an incentive to exercise a more restrictive fiscal policy. This argument becomes even stronger in case of a hard peg regime like a monetary union or a currency board, as the political costs of repealing such a system are higher compared to a realignment under a soft peg. This is demonstrated by Fatas and Rose (2001) and it is also an essential assumption in the theoretical analysis of currency board arrangements by Irwin (2004).

In the following, we give an overview of the theoretical models and empirical findings, analyzing the impact of a fixed exchange-rate regime – and especially for the case of a currency board arrangement – on fiscal policy. We begin with the work of Tornell and Velasco (1995a, 1995b, 1995c and 1998). In the theoretical parts of their models the effect of a fixed exchange-rate regime on fiscal policy is not uniquely determined, which is against conventional wisdom. They distinguish in their model between two systems:
(i) money-based stabilization, where the central bank sets the money growth rate to some constant and the exchange rate is obtained endogenously, and
(ii) exchange-rate stabilization, where the nominal devaluation rate is treated as a constant (and could also be set equal to zero e.g. for the currency board case) and the money supply

remains pegged to its initial level and no realignment takes place, i.e. both the currency board and the standard peg survive the first period and are not replaced in period 2.

is determined endogenously.

They show that fiscal discipline is in both systems influenced by the fiscal authority's intertemporal discount factor and by the level of the interest rate. Their main findings are that money-based programs induce more fiscal discipline if the fiscal policy makers are *impatient*, i.e. if the policy maker puts a greater weight on present utility than on future utility. Exchange-rate based programs lead to a higher discipline of fiscal policy, however, if the fiscal authorities are *patient*.

The intuition behind is that the choice of each system can be considered as a certain rule to distribute the burden of the inflation tax intertemporally. Operating under a peg system, the real exchange rate is determined by the central bank. Thus, fiscal authorities can execute higher expenditures financed by an increasing level of debt or a reduction of foreign reserves in the short-run. Resulting from the fact that indicators like e.g. foreign reserves are not transparent enough under a fixed exchange-rate system to reveal significant fiscal imbalances, especially for the case of transition and developing countries, the punishment of an unsound fiscal policy may be delayed to some future point in time where the situation becomes "more unsustainable" and the peg collapses. In contrast, under a flexible exchange rate system an unsound fiscal imbalance is recognized by the private sector in the short run, which leads to an expectation of higher future money growth and thus to an immediate rise in the inflation rate.

These results are confirmed empirically by several studies of Tornell and Velasco (1995a, 1995b, 1995c and 1998). However, the authors do not distinguish between soft and hard fixed-exchange rate regimes and focus on Sub-Saharan countries during the 1980s and Latin American Countries from 1960 to 1994, a time horizon where currency board systems played no major role in those geographical regions.[2]

In a similar examination, Hamann (2001) compares *exchange-rate based stabilization programs* to the broader class of *other stabilization programs*. The data used comprises 143 countries over the years 1960-1997 and includes stabilization via the adoption of a hard peg in Ecuador (dollarization) and Argentina (currency board). The author draws a conclusion which is in line with the results of Tornell et al.: The key argument in favor of an exchange-rate based stabilization, to gain fiscal discipline by reducing the inflation bias, is not confirmed in the data. However, Hamann does not distinguish between currency boards and other fixed exchange-rate systems.

In contrast, in their empirical analysis on this topic Fatas and Rose (2001) split up countries with fixed exchange-rate regimes classified as hard pegs into countries belonging to a currency area, dollarized countries and countries operating a currency board. They show that belonging to a currency area – as for example to the European Monetary Union – or dollarization are not automatically accompanied by a greater fiscal discipline. For a monetary union, the results depend on the number of participating countries. Though, they find that currency board countries are associated with a more restrained fiscal policy compared to the rest of the countries considered in their sample, also relative to countries operating under other fixed exchange-rate regimes. Furthermore, they show that the bud-

[2] In the Latin America sample only the very early years of the Argentinean currency board arrangement are observed (1991-1994). As the time series of that sample starts from 1960, the currency board effect may be negligible when considering the performance of Argentina relative to other countries.

get in currency board countries is shifted to components providing more social insurance like transfers, subsidies and social security taxes, which contribute to a sound domestic environment, too.

A further examination of the linkage between exchange rate regimes and fiscal restraints is done by ALBEROLA and MOLINA (2002). In a theoretical model which analyzes the financing of government expenditure, the authors consider two instruments, namely *monetary* and *fiscal seigniorage*. Monetary seigniorage is defined as the process of money creation and fiscal seigniorage as the increase in public debt holding by the central bank. Based on an estimation using a broad IMF data set, it is shown that monetary seigniorage has no significant influence on the fiscal deficit, whereas fiscal seigniorage by its nature has. As sketched in their model, a standard fixed exchange-rate regime does not increase fiscal discipline as there is no prevention from creating fiscal seigniorage. However, under a currency board system claims of the government disappear (or are reduced significantly) from the balance sheet due to the strict features of the currency board, which are fixed by law. Therefore, fiscal seigniorage is strongly decreased under a currency board arrangement or even completely impossible in an orthodox system.[3] They come to the conclusion that a currency board arrangement creates fiscal discipline and cement their results by an empirical investigation.

GRIGONYTÉ (2003) analyzes the impact of currency boards on fiscal discipline in ten central and eastern European countries. By estimating cross country regressions the author exhibits that the three currency board countries Estonia, Lithuania, and Bulgaria show a certain degree of fiscal discipline. The econometric studies suggest that a currency board arrangement decreases government expenditure and improves the public balance. The result can also easily be seen from the raw data, where the three countries show a level of debt relative to GDP clearly below the average level of the rest of the countries belonging to the European Union. Furthermore, Estonia and Lithuania attained fiscal surpluses over the recent years and were also far above the average of the sample.

3 Model

We consider a small open economy with a credibility problem caused by macroeconomic instabilities like e.g. a currency or debt crisis or by a lack of experience in policy-making during a transition period. The economy comprises the monetary authority, a government which decides upon fiscal policy, and the private sector. The monetary authority does not necessarily make its decisions independently, but may be influenced or overridden by the national government (TORNELL and VELASCO, 1998).

The output gap in period t is given by a modified Lucas-supply function of the form

$$y_t = \gamma(\pi_t - \pi_t^e) + wg_t \qquad \gamma, w > 0 \ . \tag{1}$$

The expression $\gamma(\pi_t - \pi_t^e)$ is a measure for the effect of surprise inflation on output: Workers demand nominal wages that are sufficiently high to cover expected average future

[3]The notion "orthodox currency board" describes a very strict interpretation of a currency board system, where the policy makers have no opportunity to make use of monetary policy instruments. This interpretation is mainly used for the theoretical analysis of currency board systems.

price increases. As unexpectedly high inflation leads ex post to lower real wages, it increases employment and, thereby, output.

Additionally, output is driven by the fiscal policy variable, g_t, which equals total government expenditure minus tax revenues and is, therefore, very close to the definition of the *fiscal deficit*. For simplification, we will use the term "government expenditure" to describe g_t, henceforth. The term wg_t reflects the impact of fiscal policy on output. We assume that government expenditure comprises, on the one hand, supply-side policy (e.g. produced output of state-owned companies or granting of subsidies), which enters the modified Lucas-supply function and, on the other hand, demand of goods from public authorities. We discuss this point more detailed, when introducing the inflation equation later in the section.[4]

Note that exactly speaking y_t denotes the deviation of output from its natural level (i.e. output gap), as log natural output is normalized to zero. For reasons of clarity, we refer to y_t by using the notion "output", henceforth.

The (real) stock of debts in period t is denoted by b_t and is given by

$$b_t = \frac{(1+r)(1+qe_t)}{(1+\pi_t)} b_{t-1} + g_t \ . \tag{2}$$

This means that the outstanding stock of debts b_{t-1} and the corresponding real interest payments plus the government spending deficit g_t have to be financed by the end of period stock of real debts b_t. The nominal interest rate r is taken as constant as we consider a small open economy with perfect capital mobility; q is the fraction of foreign debts on total debt, which is taken exogenously, and e_t denotes the percentage change of the nominal exchange-rate in price notation.

In the following, we define $\tilde{b}_{t-1}$ as the outstanding level of debt plus interest rate payments, i.e. $\tilde{b}_{t-1} := (1+r)b_{t-1}$. Then, we can rewrite equation (2) as

$$b_t = \frac{(1+qe_t)}{(1+\pi_t)} \tilde{b}_{t-1} + g_t \ . \tag{3}$$

Multiplying the first summand by $1 = (1-\pi_t)/(1-\pi_t)$ yields

$$b_t = \frac{(1+qe_t)(1-\pi_t)}{1-\pi_t^2} \tilde{b}_{t-1} + g_t \ . \tag{4}$$

Furthermore, as π_t is assumed to be a small number close to zero, we use the approximation $\pi_t^2 \approx 0$ and obtain

$$b_t = (1 - \pi_t + qe_t - q\pi_t e_t)\tilde{b}_{t-1} + g_t \ . \tag{5}$$

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[4]The assumption that fiscal policy can affect both the demand and the supply side is primarily used for mathematical purpose to avoid corner solutions. In our analysis, we focus on a demand-side oriented fiscal policy, as this seems to be the case which accords best with reality for developing and transition countries. Therefore, w should be of small size. From a theoretical aspect, however, the two possible directions of fiscal policy leave room for more flexibility for the application of our basic model.

As $q\pi_t e_t$ is approximately zero (again following the same idea as above), we finally obtain the resource constraint for the government, which is given by

$$b_t = (1 + qe_t - \pi_t)\tilde{b}_{t-1} + g_t \ . \tag{6}$$

The resource constraint used here is similar to that in SACHS, TORNELL and VELASCO (1996) and ALOY, MORENO and NANCY (2003).[5] Now, it is obvious that a devaluation, i.e. an increasing e_t, increases (foreign) debts directly. In contrast, a higher inflation rate π_t leads to a decrease of the overall debt level. Government expenditure g_t and the stocks of debts b_t and b_{t-1} are measured as shares of GDP. This seems to be most in line with the definition of the natural output, which was normalized to one (log natural output was normalized to zero, respectively).

To motivate the inflation equation used in our later analysis, it is necessary to look more precisely on the idea of its derivation. It is assumed that in the considered economy there exist tradeable and non-tradeable goods.[6] Hence, inflation in period t is given by the weighted sum of inflation in the tradeable good sector, π_t^T, and inflation in the non-tradeable good sector, π_t^N. We can formulate the following equation:

$$\pi_t = \xi\pi_t^N + (1-\xi)\pi_t^T \ , \quad 0 \leq \xi \leq 1 \ , \tag{7}$$

where ξ denotes the weight of non-tradeable goods relative to all consumption goods. We assume that in the tradeable good sector firms act under perfect competition, so that the stochastic purchasing power parity holds. Then, inflation in the tradeable goods sector equals

$$\pi_t^T = \pi_t^* + e_t + \varepsilon_t \ , \tag{8}$$

where π_t^* denotes foreign inflation, e_t the change of the exchange rate in period t, and ε_t is a random PPP-shock. We assume that the considered economy pegs its exchange rate to a stable anchor currency like for example the US-$, EUR or JPY to (re)gain credibility of its domestic currency. Hence, it is no major restriction to assume that the foreign inflation rate π^* is relatively low and can, thus, in the further analysis be considered as being approximately zero.

In the non-tradeable sector, a certain degree of price-inflexibility caused for example by price regulations in the good market sector and labor market frictions is supposed to occur. Inflation for non-tradeable goods is given by

$$\pi_t^N = \widetilde{\pi}_t + \iota g_t \ , \tag{9}$$

where $\widetilde{\pi}_t$ reflects the part of inflation which depends on the asymmetric shock ε_t, on exchange rate movements,[7] on wage-setting behavior of firms in the non-tradeable sector

[5] SACHS et al. also include a seigniorage term $\mu(\pi_t - \pi_{t,t-1}^e)$, which is neglected in our analysis.

[6] The degree of openness of an economy in this model is considered as the fraction of tradeable goods relative to all produced goods of this economy (and is thus mainly represented by κ and β, two parameters we will introduce on the next page). Note that this definition is not typical. Usually openness is defined as export volume relative to GDP or as the sum of exports and imports with respect to GDP.

[7] We assume that a move of the nominal exchange rate changes the price of some input goods, which lead also to a certain adjustment of output prices in the non-tradeable sector. However, the existence of price rigidities hampers a complete adjustment of prices and some inflation inertia – i.e. the need for further adjustment in the following periods – remains.

and on the degree of price stickiness (which is closely linked to the wage-setting behavior).[8] The last term of (9) represents the effect of government expenditure used for demand of goods to create surprise inflation, where $\iota > 0$ is a weight factor. We assume to have a complete home-bias in government expenditure which means that public demand comprises only home-produced goods.

To summarize, fiscal policy works in two directions: A fraction of government expenditure is used to raise supply of goods, as mentioned when explaining equation (1) and the rest is used for demand of goods aiming on pushing output above its natural level by creating unanticipated inflation. The latter case is the reason for having a time-inconsistency problem of fiscal policy and monetary policy at the same time.

Referring to equation (7) and the idea briefly sketched above, overall inflation in period t can be formulated as

$$\pi_t = \kappa e_t + \beta g_t + \phi_t \ , \quad 0 \leq \kappa \leq 1 \text{ and } \beta > 0 \ . \tag{10}$$

The exact size of the parameters κ and β depends mainly on the extent of wage and price rigidities which are included in $\widetilde{\pi}_t$. If markets were completely flexible, κ would be equal to one and β equal to zero, i.e. the stochastic purchasing power parity would hold for both the tradeable and the non-tradeable sector.[9]

Finally, ϕ_t is a random shock, which describes the current effect of the PPP-shock ε_t on overall inflation π_t. We assume that ϕ_t follows an AR(1)-process:[10]

$$\phi_t = \eta \phi_{t-1} + u_t \ , \quad \eta \in (0,1) \ , \tag{11}$$

where the shock innovations u_t are identically, independently distributed with zero mean and $\sigma_u^2 > 0$ for all t. We, additionally, assume in the sections 4 and 5.1 that there is no inherited shock from the first period, i.e. $\phi_1 = u_1$. We depart from this assumption in subsection 5.2 to establish a fair comparison of a currency board and a peg and allow for some shock persistence from period zero.

To motivate the inflation equation from the viewpoint of empirical evidence, we refer to Catão and Terrones (2003): They have shown by using a sample of 107 countries over the period from 1960 until 2001 that there is a strong positive association of fiscal deficit and inflation.[11] This result can be used as a further justification of the form of our inflation equation and especially for the influence of government expenditure g_t on

[8]We forbear from a formal exposition of $\widetilde{\pi}_t$ as a function of all the enumerated effects to keep the number of parameters and variables tractable. Note, that in this context the wage-setting argument is used for a more tangible motivation of some parameters, although the labor market is not explicitly introduced into the model.

[9]In principal, $\beta < 0$ would also be possible if fiscal policy is mainly characterized by granting production subsidies. As this seems to be highly implausible for developing countries and emerging market economies, on which we focus here, we strictly exclude $\beta < 0$.

[10]ϕ_t represents an asymmetric shock that changes the equilibrium real exchange rate, which reflects e.g. asymmetric business-cycle movements, demand-side effects and exchange rate movements between the anchor currency and the currencies of third countries. $\phi_t > 0$ corresponds to the necessity of a real appreciation and $\phi_t < 0$ corresponds to the necessity of a real depreciation, respectively.

[11]The sample used in Catão and Terrones (2003) comprises advanced countries, emerging-market

inflation. Remember in this context that, by definition, g_t is closely linked to the fiscal deficit.

The policy makers' objective is to minimize a quadratic loss function which depends on present and future expected inflation, and output as well as on outstanding debt at the end of the world T. The intertemporal loss function is given by

$$\begin{aligned} \Lambda_t &= \sum_{s=t}^{T} \rho^{s-t} E_t \left[L_s(\pi_s, y_s) \right] + \frac{1}{2} \rho^{T-t} \theta_b E_t \left[b_T \right]^2 + \rho^{T-t} \delta c^i \qquad (12) \\ &= \sum_{s=t}^{T} \frac{1}{2} \rho^{s-t} E_t \left[(\theta_\pi \pi_s^2 + (y_s - k)^2) \right] + \frac{1}{2} \rho^{T-t} \theta_b E_t \left[b_T \right]^2 + \rho^{T-t} \delta c^i, \end{aligned}$$

where ρ is the government's intertemporal discount factor, $E(b_T)^2$ is the expected loss resulting from outstanding real debt in the final period T and $\theta_b > 0$ is the policy makers' relative weight on these debts.[12] Analogously, θ_π is the policy makers' relative weight of the inflation target. Political costs c^i arise, whenever a policy maker under a fixed exchange-rate system, i.e. for our case under a standard peg or a currency board, decides to realign its exchange rate peg or central rate, respectively. δ is a dummy variable, which equals one when leaving the peg or the currency board and equals zero otherwise. The superscript i of political costs denotes the type of the exchange-rate system to be withdrawn, i.e. a standard peg system or a currency board arrangement. The policy maker wants to push output above its natural level, which is characterized by the parameter k. Therefore, the parameter k together with the weight of the inflation target θ_π, can be considered as the main factors which determine the time inconsistency problem of the policy makers.

We restrict our further examination to a time-horizon of two periods, by focussing on the policy makers' decisions for the second period. Therefore, we rewrite (12) and consider the second-period loss under the assumption that the "world will end after that period". Then, L_2 is given by[13]

$$L_2 = \frac{1}{2} \left[(y_2 - k)^2 + \theta_\pi \pi_2^2 + \theta_b b_2^2 \right] + \delta c^i \ . \qquad (13)$$

To summarize, the government dislikes inflation and debts, however, it prefers more output to less, even beyond the natural output level (depending on k). The structure of the model implies that several trade-offs may occur, which are illustrated by the *Trade-off Triangle* in figure 1 and explained in the following.

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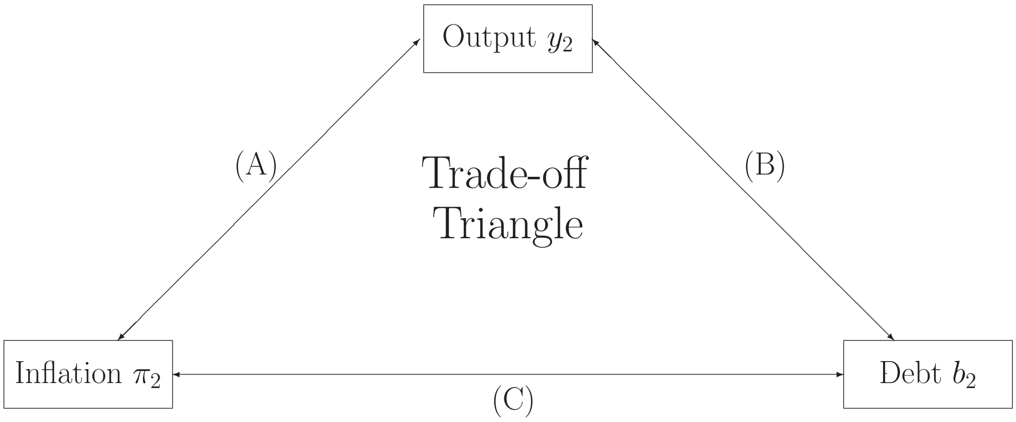
countries and other developing countries. They find that "fiscal deficits have been shown to matter not only during high hyperinflations but also under moderate inflation ranges [...]". Furthermore, the positive correlation between the fiscal deficit and inflation appeared significantly in all groups of countries and "surprisingly strong over a broad range of developing countries [...] ", (p.26). These are exactly the countries in the center of our analysis.

[12] By applying the debt term in the loss function, we guarantee that debt accumulation is not for free: This means that we avoid costless accumulation of debt, which prevents the policy maker from creating an unlimited amount of debts.

[13] Note that the intertemporal exposition of the loss function is needed to motivate the second-period debt term $\theta_b b_2^2$ in the loss function.

Figure 1: Debt-, Inflation- and Output Target



A) *Inflation-output Trade-off:* On the one hand, the policy maker has an incentive to push output above its natural level by creating surprise inflation, on the other hand, inflation itself contributes directly to the policy loss.

B) *Output-debt Trade-off:* Fiscal policy has an incentive to push output to the desired level via its policy instrument g_2, at the same time fiscal policy (or to be more precisely the fiscal deficit) has to be financed by an increasing debt which accounts by itself for a policy loss.

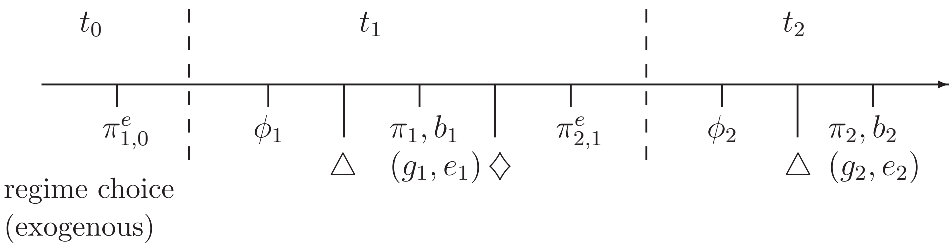
C) *Debt-inflation Trade-off:* On the one hand, the policy maker has an incentive to lower its real debt level by a rise of the inflation rate, on the other hand, inflation itself contributes directly to the policy loss.

Timing of Political Decision-Making

A key feature of the currency board is its establishment by law. Enoch and Gulde (1998) consider a sound legal basis as an essential issue when introducing a currency board, "because a currency board arrangement derives much of its credibility from the changes required in the central bank law concerning exchange rate adjustments", (p.42). The legal anchor of the currency board arrangement gives reason that an abandonment of the system is not possible over night. As a currency board is established by law, we state that it can only be repealed, if this was announced one period in advance, i.e. before the private sector made its expectations on inflation. The sequence of decision-making of the private sector and the fiscal and monetary authority is depicted in figure 2.[14] In our model, the decision whether to repeal the currency board in a certain period or not

[14] As we, typically, consider countries with a credibility and stability problem, the central bank may not be acting independently as aforementioned. Therefore, we assume that the central bank and the government act simultaneously and can be considered as a "single authority". We further assume, that strategic behavior of fiscal and monetary authorities does not matter here.

Figure 2: Sequence of the Model



is announced one period in advance – here in the picture at time $\diamondsuit$ before the private sector forms second period expectations $\pi^e_{2,1}$.

In the case of a standard peg, the fixed exchange rate can be abandoned after observing the shock which would actually be possible in each period and is labeled in figure 2 by $\triangle$. As we presume that a standard peg has some commitment value, too, we assume that the policy maker will leave the peg earliest after the realization of ϕ_2. This means that a standard peg system survives at least in the first period after its introduction.[15] The private sector has rational expectations about inflation $\pi^e_{2,1}$, which are formed before the future shock ϕ_2 is observed. For a better understanding of the sequence, we use in figure 2 the notation $\pi^e_{2,1}$ for the private's expected inflation of the second period, which was created in the first period. For reasons of brevity we use in our calculations only the first indicator, which means $\pi^e_{2,1}$ is rewritten as π^e_2.

If the exchange rate is fixed, the monetary authority has to abstain from an active policy and surprise inflation can only be created by a rise in government expenditure g_t. If the exchange rate is flexible, inflation can be influenced by a change of the nominal exchange rate and by fiscal policy.[16]

4 Government Debts and Fiscal Discipline

4.1 Comparison of a Currency Board and a Standard Peg Regime

Subject of this section is to find out whether a standard fixed-exchange rate regime or a currency board system induces higher fiscal discipline and a more conservative amount of debts. Hence, we do not focus on the decision of maintaining or abandoning both types of fixed exchange-rate regimes. In fact, we aim at a ***comparison of the fiscal policy and the choice of the debt level under a currency board and a standard peg while both systems are maintained.***

To be more precisely: The idea is to elaborate a theoretical explanation for the findings of the (empirical) literature demonstrated in section 2, which says that currency

[15] We do not model the optimal regime choice. In this model, we compare the losses occurring under a standard peg regime and a currency board system. Both systems are introduced in period 0.

[16] Note that in figure 2 the arguments in the brackets, g_t and e_t, are the policy variables of the fiscal and monetary authorities through which the targets π_t, y_t and b_t are determined.

board systems increase fiscal discipline. Therefore, we compare losses occurring under both exchange-rate regimes from an *interim perspective*.[17] This means that we make the assumption that the fixed exchange rate is maintained in the second period under both regimes (a standard peg and a currency board), but their survival *was not obvious ex ante* and, therefore, the private sector may have a positive devaluation expectation under a peg.

The optimization problem under both systems follows the same pattern. The systems differ only from the expected inflation rate of the private sector due to the different timing of political decision-making. We refer to this point again at the end of this subsection.

As the monetary authorities abstain from a devaluation, the resource constraint is simply given by

$$b_2 = b_1 - b_1\pi_2 + g_2 \ . \tag{14}$$

Note that we have no longer to distinguish between domestic and foreign debts, because exchange rate movements are excluded here: Neither a revaluation, which would reduce the net value of real foreign debts, nor a devaluation, which would increase the real foreign debt level, will take place. The policy maker optimizes the second period loss function

$$L_2 \ = \ \frac{1}{2}(y_2 - k)^2 + \frac{1}{2}\theta_\pi \pi_2^2 + \frac{1}{2}\theta_b b_2^2$$

with respect to the debt restriction (6), the output equation (1) and the inflation equation (10). The first order conditions of the problem are given by

$$\begin{aligned} (y_2 - k) + \lambda_1 &= 0 && (15)\\ \theta_\pi \pi_2 - \gamma\lambda_1 + \lambda_2 + \lambda_3 b_1 &= 0 && (16)\\ \theta_b b_2 + \lambda_3 &= 0 && (17)\\ w\lambda_1 + \beta\lambda_2 + \lambda_3 &= 0 \ , && (18) \end{aligned}$$

and by the three restrictions (1), (6) and (10).

For a better exposition, we define $A := w + \gamma\beta$ and $B := (1 - \beta b_1)$. Due to the domain of the parameters, it is obvious that A is strictly positive. B is also assumed to be positive, as for developing countries and transition economies total government debt ratios, b_1, lie typically between 20% and 60% of GDP and as the parameter β is supposed to be sufficiently small. Note in this context that the Argentinean default on sovereign debts in 2002 happened to be at a level of public debts of around 60% of GDP. Applying the abbreviations A and B, we obtain the optimal debt value

$$b_2^* = \frac{(k + \gamma\pi_2^e + wb_1)AB}{\theta_b B^2 + A^2 + \theta_\pi \beta^2} - \frac{(\phi - \beta b_1)(\theta_\pi \beta + A(\gamma + wb_1))}{\theta_b B^2 + A^2 + \theta_\pi \beta^2} \ . \tag{19}$$

We also obtain the optimal values for π_2, y_2 and g_2 given by

$$\pi_2^* = \frac{\beta A(k + \gamma\pi_2^e) + \phi_2(\theta_b B + wA) - \theta_b \beta B b_1}{\theta_b B^2 + A^2 + \theta_\pi \beta^2} \ . \tag{20}$$

[17] Note that it makes no sense to compare fiscal policy outcomes of both fixed exchange-rate regimes, if one or both systems have already been repealed. This problem belongs to another interesting aspect, i.e. the stability of both systems, and is analyzed in section 5.1.

The optimal rate of inflation depends positively on the second period shock, ϕ_2, and it is pushed by the desired output level k above its natural level. On the contrary, a higher weight of the debts in the loss function, θ_b, may reduce inflation: In the considered case, the central bank cannot create inflation to reduce (the domestic part) of the real public debts, because the exchange rate is fixed. Therefore, a reduction of government expenditure, which actually lowers inflation, remains the only way how fiscal policy can reduce debts. A higher weight of inflation in the loss function, θ_π, makes inflation more costly and, hence, contributes to lower inflation.

Optimal output amounts to

$$y_2^* = \frac{kA^2 - \theta_b b_1 AB - \gamma\pi_2^e(\theta_b B^2 + \theta_\pi\beta^2) + \phi_2(\theta_b B(\gamma + wb_1) - \theta_\pi w\beta)}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} , \qquad (21)$$

where y_2 depends positively on the second period shock, ϕ_2, due to our assumption of a very small ω and a relatively small β. Output depends also positively on the desired output target k.

The optimal fiscal policy is given by

$$g_2^* = \frac{(k + \pi_2^e)A + \phi_2(\theta_b B - \theta_\pi\beta + A(w + \gamma + wb_1)) + b_1(A(\gamma\beta - 1) + w - \theta_b B)}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} , \qquad (22)$$

where a high desired output target k and a large γ, the parameter which measures the effect of surprise inflation on output, both lead to an incentive to create surprise inflation by raising demand and, hence, contribute to the policy makers' optimal choice of a higher fiscal deficit g_2. In contrast, an extremely high θ_b reduces government expenditure as the reduction of debts is of major interest.

In the following, we calculate the first derivatives of the policy variables with respect to π_2^e and show that the signs are univocally determined:

$$\frac{\partial b_2}{\partial \pi_2^e} = \frac{\gamma AB}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} > 0 \qquad (23)$$

$$\frac{\partial \pi_2}{\partial \pi_2^e} = \frac{\gamma\beta A}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} > 0 \qquad (24)$$

$$\frac{\partial g_2}{\partial \pi_2^e} = \frac{A}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} > 0 . \qquad (25)$$

As the expected inflation rate under a currency board is according to empirical evidence smaller compared to the expected inflation under a standard peg regime, the following result holds:[18]

Result 1. *The lower π_2^e the higher is the discipline of fiscal policy and the lower are the debts under the condition that the exchange rate is not changed.*

[18]Empirical evidence and a theoretical proof of $\pi_2^{e,CB} < \pi_2^{e,Peg}$ is added in the following subsection. To be more accurate, the lower expected inflation rate under a currency board compared to a standard peg regime can be traced back to a lower expected devaluation under a currency board compared to a peg.

As a currency board is associated with a lower expected inflation compared to a standard peg system, a currency board leads to more fiscal discipline and to a lower debt level.

Furthermore, we can show that

$$\frac{\partial y_2}{\partial \pi_2^e} = -\frac{\gamma(\theta_b B^2 + \theta_\pi \beta^2)}{\theta_b B^2 + A^2 + \theta_\pi \beta^2} < 0 \ , \tag{26}$$

i.e. output depends negatively on the inflation expectations. This stands in line with the empirical findings of e.g. GHOSH et al. (2000) when analyzing the effects from introducing a currency board arrangement on economic growth. Therefore, we draw the following conclusion:

Result 2. *The choice of a currency board can contribute to a higher growth of output due to the lower inflation expectations of the private sector.*

4.2 Inflation Expectations

In this subsection, we compare the expected inflation of the private sector under a currency board system and a standard fixed exchange-rate regime. At first, we derive the condition for which the expected inflation rate is lower under a currency board arrangement than under a standard peg by using a theoretical approach to justify the assumption made in the previous subsection. Subsequently, we refer to empirical work suggesting that a currency board system may contribute to higher credibility which is expressed by lower inflation expectations.

Theoretical Approach

To derive inflation expectations, we use a similar calculation as in section 4.1. The policy maker optimizes the following Lagrangean, where we introduce e_2, which denotes the change of the second period exchange rate:

$$\begin{aligned} \mathcal{L}_2 \ &= \ \frac{1}{2}(y_2 - k)^2 + \frac{1}{2}\theta_\pi \pi_2^2 + \frac{1}{2}\theta_b b_2^2 \\ &\quad +\lambda_1(y_2 - \gamma(\pi_2 - \pi_2^e) - w g_2) \\ &\quad +\lambda_2(\pi_2 - \phi_2 - \kappa e_2 - \beta g_2) \\ &\quad +\lambda_3(b_2 - b_1(1 + q e_2 - \pi_2) - g_2) \ . \end{aligned} \tag{27}$$

At first, we treat e_2 like an additional parameter. The idea is to derive the expected inflation rate depending on an expected change of e_2, to show in which direction a devaluation drives the expected inflation π_2^e.[19]

[19] Our analysis is limited to cases of a devaluation, as the need of an appreciation under a fixed exchange-rate regime is assumed to be less problematic as it usually does not indicate a typical crisis scenario and is thus less interesting for the purpose of our analysis.

The calculation follows the same pattern as in the previous subsection. By assuming rational expectations of the private sector, expected inflation π_2^e is determined by

$$\pi_2^e = \frac{\beta Ak + \eta\phi_1(\theta_b B + wA) - b_1\beta\theta_b B + e_2^e(w\kappa A + \theta_b B(\kappa - \beta b_1 q))}{\theta_\pi\beta^2 + wA + \theta_b B^2} \ . \tag{28}$$

Due to the announcement of maintaining or abandoning the currency board one period in advance, the expected inflation rate under a currency board is given by

$$\pi_2^e\Big|_{e_2^e=0} = \frac{\beta Ak + \eta\phi_1(\theta_b B + wA) - b_1\beta\theta_b B}{\theta_\pi\beta^2 + wA + \theta_b B^2} \ . \tag{29}$$

Under a standard peg regime, a sudden realignment after the observation of the second period shock, ϕ_2, is possible. How the private sector's expectation about second period inflation is influenced by an expected devaluation of e_2^e is given by

$$\frac{\partial\pi_2^e}{\partial e_2^e} = \frac{w\kappa A + \theta_b B(\kappa - \beta b_1 q)}{\theta_\pi\beta^2 + A^2 + \theta_b B^2} \ . \tag{30}$$

If foreign debts are not too high represented by a relatively small value of q and the economy is quite open (represented by κ approaching one), the sign of the terms inside the brackets is positive and an expected devaluation causes an increase of privates' inflation expectations.

Furthermore, we know from the common literature that by assuming a certain distribution of the new shock u_2, multiple equilibria may occur under a standard peg regime. As we do not focus on the exact value for the inflation expectations of both systems, but on a qualitative comparison, we do not calculate the equilibria explicitly. If we assume that an appreciation of the exchange rate is excluded as in the graphical explanation of the equilibrium exchange rate in Obstfeld (1996), i.e. $e_2 \geq 0$, we can avail ourself on the fact that the private sector is aware that with a certain probability – depending on the realization of the second period shock – the policy maker will make use of her escape clause and devalue the currency under a standard peg system. Therefore, we can state that the expected inflation rate is a (probability weighted) mixture of the expected inflation rate for the case of defending the peg, which equals that of a currency board system given by (29), and for the case of devaluing the exchange rate, given by equation (28). According to the sketched idea, the following result holds:

Result 3. *The private sector has a lower expected inflation under a currency board arrangement than under a standard peg system, if* $(w\kappa A + \theta_b B(\kappa - \beta b_1 q)) > 0$.
This condition is unambiguously fulfilled if the fraction of foreign debts relative to total debts is not too large and the economy is relatively open, i.e. $\kappa > \beta b_1 q$.[20]

As a stable fixed exchange-rate system is typically accompanied by a relatively small ratio of foreign debts to total debts and a high openness towards the anchor currency, κ, it may be no major restriction to use result 3, which states that $\pi_2^{e,CB} < \pi_2^{e,Peg}$, in section 4.1.

[20] If we consider the extreme case that a standard peg is highly credible, i.e. the probability of a devaluation equals zero, the expected inflation is the same under both systems.

However, the opposite may be true for a relatively closed economy characterized by a small value of the parameter κ and a large amount of public debts denominated in the foreign currency: If the government devalues its currency, the real value of outstanding debts increases. Therefore, a high level of foreign debts can have two different effects: It may prevent the government from a devaluation and thereby implies fiscal discipline or it may force the government to default on its debts as it happened in Argentina in 2001.

Note that it is easy to understand the argumentation used here, when a revaluation of the exchange rate is excluded. However, when referring to the common literature on time inconsistency, a desired output level above the natural level creates an inflation bias, which makes a devaluation more likely than a revaluation. Therefore abstaining from the possibility of revaluation is not necessary for obtaining result 3, but makes it more easy to capture the line of arguments and avoids at the same time the distinction of further cases, which are necessary to examine when inherited shocks and debts from the past are considered.

Empirical Findings

The two common proceedings to estimate inflation expectations are to evaluate survey data or to use the difference of the nominal and real interest rates of non-indexed and indexed governments bonds as a proxy for expected inflation. Survey data can only be obtained for Bulgaria and government-bond yields (especially those of indexed bonds) are hardly available for any currency board country on a monthly basis, which would be necessary to obtain enough observations for a meaningful estimation. Therefore, we abstain from an own estimation and refer to two empirical papers, which suggest that expected inflation under a currency board is lower than under a standard fixed exchange-rate regime.

Ghosh et al. (2000) compare inflation rates for countries with currency boards and standard peg regimes and show that inflation under currency board regimes is lower than under standard fixed-exchange rate regimes. The findings can be used for claiming from an ex post view that also the inflation expectations should be lower when operating a currency board.

Carlson and Valev (2000) use survey data for Bulgaria to analyze whether the introduction of a currency board system lowers expectations of inflation. The survey was conducted a short time before the currency board was introduced and a follow-up survey was conducted 10 months later. The authors show that already in the first survey, the people had a lower expected inflation rate due to the near introduction of the currency board arrangement. In the follow-up survey, it became obvious that the introduction of a currency board did indeed lower inflation expectations as well as actual inflation rates.

5 Stability of a Currency Board System

We analyze the stability of currency board systems by focussing on two aspects. First, we try to figure out under what conditions a policy maker operating a currency board system announces the continuity or the abandonment of the currency board. We examine thoroughly how the change of some characteristic parameters like e.g. the policy makers' desired output deviation k, the volatility of the PPP-shock σ_u^2, the inherited shock from the first period $\eta\phi_1$, the inherited debt level b_1 or the fraction of foreign debts on total public debts q can influence the policy makers' decision. We use a numerical approach to obtain the results.

Second, we compare the stability of a currency board system with that of a standard fixed exchange-rate regime for a given set of parameters. Here, we use a similar concept of the *credibility of an exchange rate system*, which is referred to the probability that the considered exchange rate regime survives the second period. Analogically to the proceedings of the first part, we examine how the variation of some characteristic parameters changes the credibility of a standard peg compared to that of a currency board system by using four numerical scenarios. We derive the conditions under which the currency board system induces a credibility advantage.

5.1 Decision-Making under a Currency Board

As the decision whether to repeal or to maintain a currency board regime is made before the "new shock" is realized, we have to compare the expected losses of the next period for both cases. We suppose that, whenever a monetary authority decides to repeal the currency board, the exchange rate will be adjusted optimally, which means that the new system can be characterized by a free floating exchange rate regime in our two-period framework.[21] The policy maker announces the continuity of the currency board system in the next period if the expected loss of the free float plus political costs c^{CB}, which arise when giving up the currency board, exceed the expected loss when maintaining the currency board. Therefore, the critical threshold where the policy maker is indifferent between both systems is determined by

$$E(L_2^{float}) + c^{CB} = E(L_2^{CB}) \ . \tag{31}$$

The solution is briefly sketched in appendix C. To gain insights into the solution, we use two numerical examples in the following for a quantitative exploration. Our analysis focusses on situations, in which the policy makers' main problem is whether to devalue or not. Therefore, we assume that besides the existence of the time-inconsistency problem, a negative shock hits the economy in the first period. We make this assumption, as we focus on examining situations characterized by the existence of a credibility problem, which usually do not occur when a currency is revaluated.

The numerical values of the parameters in a first scenario and a short explanation of each parameter are depicted in table 1. In this scenario, the expected second period loss under a currency board system is lower compared to a free float system. The exact numerical values for the expected losses in both cases are shown in table 2. Therefore, in this scenario the policy maker would announce the continuity of the currency board in period 1 — before the privates negotiate their wages (= build their expectation of the second period inflation rate) and before the PPP-shock of the second period hits the

[21] Note that in this subsection, when referring to the free float system, we discuss the case of announcing the abolishment of the currency board arrangement.

Table 1: Numerical Example, Scenario I

Parameter	Numerical Value	Explanation
k	0.02	Desired output deviation from the natural level
γ	1.00	Effect of surprise inflation on output
w	0.09	Effect of fiscal policy on output
		(only fiscal policy addressed upon the supply side)
b_1	0.20	Inherited stock of public debts
q	0.30	Ratio of foreign public debts to total public debts
κ	0.80	Effect of the change of the exchange rate on inflation
β	0.30	Effect of fiscal policy on inflation
		(only fiscal policy addressed upon the demand side)
ϕ_1	-0.03	PPP-shock of the first period
σ_u	0.02	Standard deviation of the PPP-shock
η	0.80	Shock persistence
θ_b	0.2	Policy makers' relative weight on debt target
θ_π	1.20	Policy makers' relative weight on inflation target
c^{CB}	0.012	Political costs

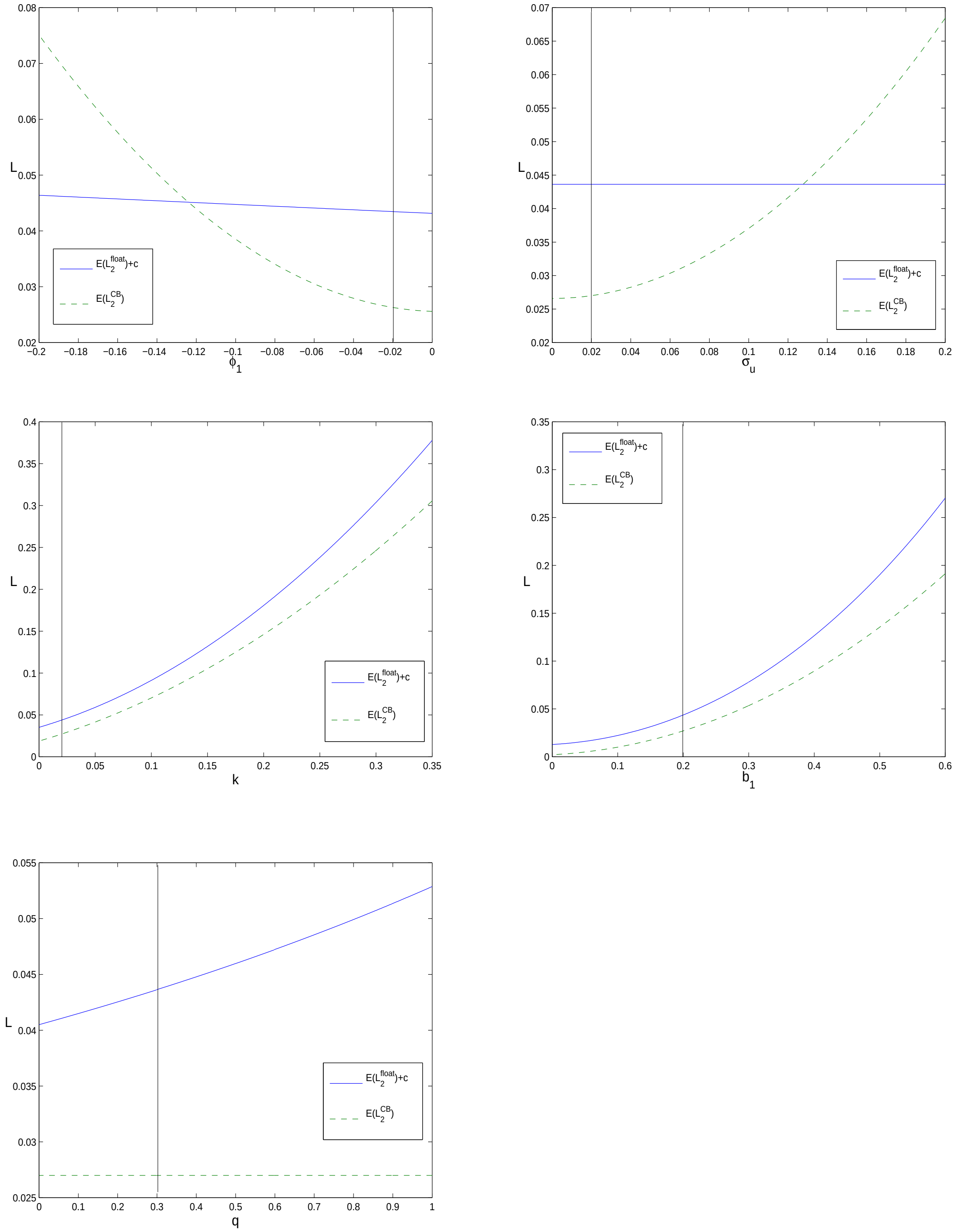
Table 2: Expected Losses in Scenario I

Expected loss under a currency board	Expected loss under a free float
$E(L_2^{CB}) = 0.0270$	$E(L_2^{Float}) + c^{CB} = 0.0436$

economy. However, we do not focus on the explicit values of the losses under this scenario. In fact, the aim is to show how the variation of a particular parameter value can influence the expected losses in both cases and, thus, the stability of the currency board system, while keeping the rest of the parameters fixed. We measure *the stability of the currency board* by the *distance of the expected loss function in the currency board and the free float case* in this section. The sensitivity analysis of the expected losses of scenario I is done in figure 3.[22] The pictures confirm the results found in Feuerstein and Grimm (2006): A high (negative) inherited shock from the first period ϕ_1 and a high volatility of the shock innovation in the second period σ_u^2 increases the expected second-period loss under a currency board relative to the expected loss under free float system. This result stems from the fact that an announcement to maintain the currency board system prevents the policy maker from offsetting the shock in the second period. Therefore, when the first period shock reaches some critical threshold the policy maker will announce to repeal the currency board in the second period to lower its expected policy loss. A high volatility of the "new shock" works in the same direction, as it increases the risk that the economy will be hit by a large shock in the second period to which the policy maker cannot react

[22]Note that the vertical line in the single plots denotes the parameter set, which was used in Scenario I.

Figure 3: Sensitivity of Expected Losses (Scenario I)



under a currency board system.

A larger desired output level, k, which together with a relatively small θ_π reflects the main cause for the time inconsistency problem of fiscal and monetary policy (i.e. fiscal and monetary policy try to create surprise inflation to raise output), leads to a higher stability of the currency board system. The time inconsistency problem of monetary policy is solved under a currency board as the monetary authorities' decision is well-known at the point in time where the privates create their expectations of inflation (see also section 4). However, the time inconsistency problem of fiscal policy given by the desire of the policy maker to create surprise inflation by raising government demand persists.

The reason for an increasing level of k to improve the stability of a currency board system, anyway, is based on the quadratic loss function, i.e. a higher deviation from the target levels leads to a disproportionately high increase of the policy loss. In the case of repealing the currency board arrangement, the policy maker can mix two instruments to raise inflation, the exchange rate (e_2) and government expenditure (g_2), whereas when maintaining the currency board only fiscal policy (g_2) is available. An increase in g_2 primarily leads to higher debts and an increase of e_2 primarily leads to an increase of inflation. As both, debts and inflation enter the loss function quadratically, the costs of each instrument increase disproportionately high by more intensive use. So, in the case of repealing the currency board, a higher value of k leads to a disproportionately higher incentive to generate surprise inflation, compared to the case when the currency board is maintained. Hence, the time inconsistency problem is more severe in the case of abandoning the currency board, which is also reflected by a higher expected inflation of the private sector.

The last two pictures of figure 3 suggest that a rise in the inherited debt level, b_1, and an increasing fraction of foreign debts on total debts, q, leads to a higher stability of the currency board system:

A rise in b_1 makes the *time inconsistence problem of monetary policy more severe*, as the monetary authority has now the incentive to create inflation for two reasons: (i) create surprise inflation to push output above the natural level, and (ii) create inflation to devalue the level of outstanding real government debts. As the currency board solves the time-inconsistency problem of monetary policy, a higher b_1 leads to a higher stability of the currency board.[23]

A higher value of q does not influence the loss if the currency board is maintained, i.e. a devaluation is excluded. However, a desired output level above the natural level and a negative first period shock (see the parameter values in example 1) as well as a high π_2^e triggers the policy maker to a relatively large devaluation when an exit of the currency board arrangement was announced before, and the exchange rate can be adjusted freely. The same devaluation leads in case of a larger q to a higher growth of real debts, where the growth rate itself depends on the size of foreign debts, meaning that a higher q contributes to higher policy loss and, hence, it makes a currency board more stable.

To abstain from sweeping something under the rug, we point out that when b_1 and k

[23]Note that we solidly focus on the consequences in variations of b_1 in our model, where we do not incorporate the possibility of a default on government debts or binding credit market constraints, which may both play a major role from a practical point of view.

are varied the result may be contrary if the policy maker puts an extremely high weight on public debts in the loss function, which is given by an extraordinary high θ_b. However, as for developing countries such an extremely conservative behavior is not observable, our results of example 1 seem to be robust with respect to the most relevant political scenarios.

In the following, we apply our analysis once more to a "stressful" scenario for a policy maker operating a currency board system. Now, a larger negative PPP-shock inherited from the first period, a higher shock volatility, a greater weight of the inflation target in the loss function and zero exit costs are assumed in scenario II.[24] The exact parameter values used here are given by table 3. The choice of the parameter set enables to exhibit

Table 3: Numerical Example, Scenario II

Parameter	Numerical Value	Parameter	Numerical Value
k	0.02	ϕ_1	-0.06
γ	1.00	σ_u	0.04
w	0.09	η	0.80
b_1	0.30	θ_b	0.20
q	0.30	θ_π	2.00
κ	0.80	c^{CB}	0.00
β	0.30		

an example in which, contrary to our first scenario, the policy maker decides to announce to exit the currency board system in the second period. We make the free float case (i.e. the incentive of abandoning the currency board) more attractive by choosing a higher policy weight of the inflation goal, a higher volatility of the new shock, a raising inherited first period shock, and exit costs of zero. The comparison of the losses of a free float and a currency board is given in table 4.

Table 4: Expected Losses in Scenario II

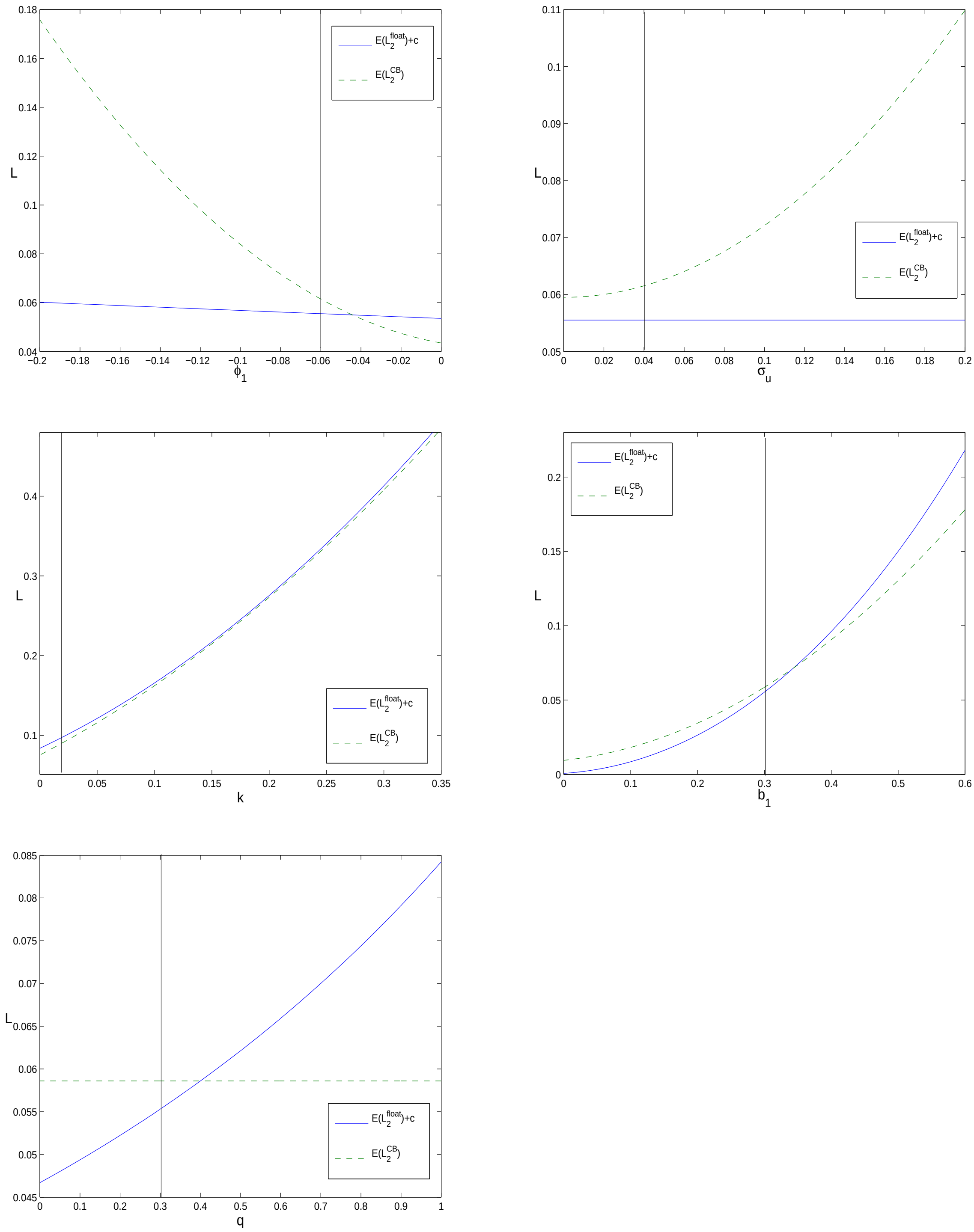
Expected loss under a currency board	Expected loss under a free float
$E(L_2^{CB}) = 0.0586$	$E(L_2^{Float}) = 0.0439$

Our main interest of the examination of example II is to find out, whether variations in the parameters $\phi_1, \sigma_u^2, k, b_1$ and q work in the same direction as in example 1. The results are depicted from figure 4.

From a qualitative view the results obtained in scenario II stand strongly in line with the results in scenario I. One more aspect, which is emphasized by the plots of this scenario, is noteworthy to mention: The pictures in the second row illustrate, that a currency board has an *intrinsic commitment value*, i.e. its stability does not solely depend

[24]The value of b_1 was also slightly increased for a better graphical exposition, but the same qualitative results could be obtained for $b_1 = 0.2$, which was used in scenario I.

Figure 4: Sensitivity of Expected Losses (Scenario II)



on the existence of the political costs c^{CB}, as we find cases in which the continuity of the currency board seems advantageous even when the exit costs c^{CB} are equal to zero. This result holds due to the characteristics of the currency board arrangement that it is defined by law and, therefore, cannot be abolished on short notice.[25] This stands in contrast to the findings of Irwin (2004).

To complete this analysis and to strengthen one central result, we take up once more the variation of k to analyze, how a more severe (overall) time inconsistency problem contributes to the stability of the currency board when directly comparing scenarios I and II.

Figure 5: Time Inconsistency Problem: Comparison of Scenario I and II

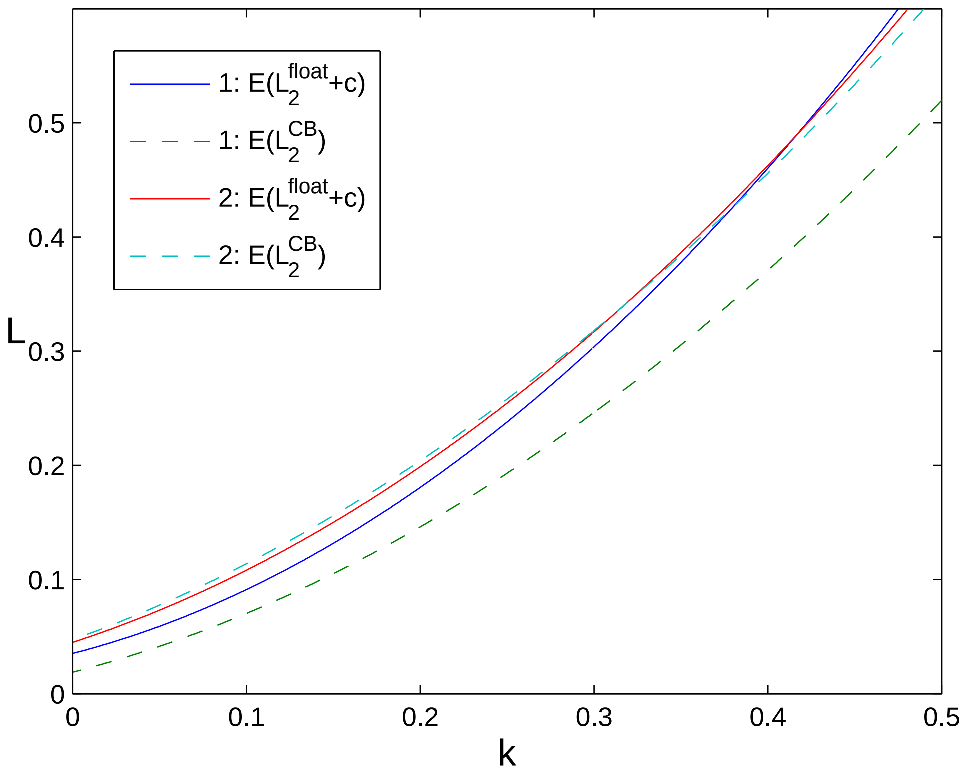


Figure 5 shows that despite a higher shock volatility, a negative inherited first period shock, and zero exit costs the loss of a currency board system is still increasing less intensely when k rises compared to the loss of a flexible exchange rate system and thus a currency board achieves a stability gain. Therefore, we emphasize once more that a currency board system can reduce the (overall) time inconsistency problem. However, for

[25] The time inconsistency problem of monetary policy is solved completely, but, the time inconsistency problem of fiscal policy remains. As aforementioned, the overall time inconsistency problem is reduced as surprise inflation is more costly if fiscal policy remains the only instrument to increase inflation. This is the reason for the intrinsic credibility of a currency board arrangement.

a given k, of course, the stability of a currency board decreases in scenario II compared to scenario I.

This subsection is concluded by a summary of the central results found in the two scenarios.

Numerical Result 4. *The stability of a currency board system – measured as the difference of the expected losses when deciding to maintain or to repeal the system – is relatively high in cases characterized by*

a) a relatively low volatility of the "new shock" u_2,

b) a relatively low inherited first period shock $\eta\phi_1$,

c) a relatively high fraction of foreign debts q,

d) a relatively high desired output level k,

e) and a relatively high inherited first period debt b_1.

5.2 Comparison of a Currency Board and a Standard Peg

The credibility of a (standard) fixed exchange-rate system and a currency board system is measured by the probability that the system survives the second period. The proceeding is motivated by the approach of Drazen and Masson (1994) and Feuerstein and Grimm (2006). The comparison of both exchange rate systems is done by using the maintaining probabilities of the systems. The technical part of this subsection is shifted to appendix D, where the support of the uniformly distributed "new shock" is characterized and the explicit formulas for the probabilities of maintaining the currency board and defending the standard peg system are derived.

In this section we refer to four numerical examples to compare the currency board system and the standard peg regime. The comparison is done in a similar way as in the previous section: We use a given set of parameters and calculate the maintaining probability of a currency board and the probability of defending the peg regime. Then we analyze how the probabilities change when the value of some parameter is varied. In our analysis, we aim at finding the absolute credibility advantage (given if one exchange rate system has a higher maintaining probability than the other one) and at the change of the difference of the maintaining probabilities caused by the variation of a particular parameter. To derive the results from our numerical examples, which are supposed to hold "more generally", we lay a greater importance into the latter case. We begin our analysis with scenario I and scenario II from section 5.1 (see tables 1 and 3). As the probability of maintaining a standard peg regime depends strongly on the exit costs, we add exit costs of $c = 0.012$ in scenario II. We, furthermore, assume that the exit costs under both systems are of the same size. Due to the nature of these costs, however, the repealing of a currency board should go along with higher political costs. Hence, the credibility of currency board may be underestimated in several cases. Therefore, the arguments in favor of a currency board are actually even stronger than stated here.

As already mentioned in previous sections, multiple equilibria may occur under a standard peg regime. We abstain here from calculating these equilibria explicitly, but assume analogously to section 5.2 that the inflation expectation of the private sector is a mixture of the inflation expectation under a free float system and a currency board system (= ultimate fix):

$$\pi_2^{e,Peg} = \alpha\pi_2^{e,float} + (1-\alpha)\pi_2^{e,CB} \quad \text{with} \quad \alpha \in [0,1] \ , \tag{32}$$

where $\pi_2^{e,CB}$ is the expected inflation under a currency board system when its continuity in the future period has already been announced. We discriminate between three cases of the private sector's inflation expectations under a peg system:

a) Full anticipated credibility: $\alpha = 0$, $\pi_2^{e,Peg} = \pi_2^{e,CB}$

b) Partial anticipated credibility: $0 < \alpha < 1$, $\pi_2^{e,Peg} = (1-\alpha)\pi_2^{e,CB} + \alpha\pi_2^{e,Float}$

c) Zero anticipated credibility: $\alpha = 1$, $\pi_2^{e,Peg} = \pi_2^{e,Float}$

Now, we can calculate the maintaining probabilities for the three peg cases and for the currency board arrangement in scenario I and II. In the following, α is set equal to 0.5 for the case of partial anticipated credibility of the privates. Table 5 shows that the currency

Table 5: Maintaining Probabilities for the Scenarios I and II

	Currency board	Peg ($\alpha = 0$)	Peg ($\alpha = 0.5$)	Peg ($\alpha = 1$)
Scenario I	1	0.9890	0.9311	0.7882
Scenario II	1	0.5773	0.5318	0.4577

board system is maintained with probability one in both scenarios, which means that the policy maker will always announce to keep on operating the currency board system. Technically speaking, the support of the shock ϕ_1 is a subset of the maintaining-interval of the currency board, which was derived in appendix D. The peg system is maintained with a slightly lower probability in scenario I, which is decreasing with an increasing level of α. Table 5 also shows that in the second scenario, the peg is maintained with a probability around 50% for all three cases of α. Therefore, the currency board has a credibility advantage compared to a standard peg in both scenarios.

Remark. *Prima facie the result seems unexpected: Although the peg system has one more degree of freedom than the currency board, i.e. a policy maker can decide whether to leave or maintain the peg after the shock realization, and although presuming that $\alpha = 0$, which means that the private sector anticipates full credibility of the peg, a currency board performs better than a standard peg. We, however, do not focus on a welfare comparison, but on a comparison of the credibility/stability of an exchange rate system. Therefore, we state that a policy maker under a currency board maintains the system with a probability of one for the given set of parameters. In contrast, the policy maker operating a standard peg system will abandon the peg and, hence, makes use of the escape clause when a large unfavorable shock occurs. For $\alpha = 0$ this can indeed be welfare-improving compared to the welfare achieved under a maintained currency board.*

Not the result of scenario I itself, but, rather the explanation which parameters exactly drive the credibility of both exchange rate systems is of major interest in the following.

Figure 6 shows, how the credibility of both systems react to variations of the characteristic parameters.

The main result, which can be drawn from figure 6 is that an increasing volatility of the new shock σ_u^2 decreases the maintaining probability of both systems, but increases the relative credibility of a standard peg regime. The result can be traced back on the timing of the policy makers' decision-making: A high volatility of the shock implies a high risk to bear a large future shock. Whereas under a currency board system a sudden exit in period 2 is not possible, the monetary authority operating a softer peg regime can do a realignment in period 2, surprisingly. Therefore, a currency board is announced to be abandoned with a higher probability in the first period, and the credibility of a standard peg relative to a currency board rises with an increasing σ_u^2.

Furthermore, figure 6 suggests that for high values of θ_b, i.e. the policy maker puts a high weight on debts in her loss function, a standard peg gains a relative credibility advantage. A high θ_b triggers the policy maker to create inflation to lower real debts, which is easily possible by a devaluation when the ratio of foreign debts to total debts, q, is small as in the considered case. Therefore, the exit clause in the second period under a standard peg may increase the relative credibility of the peg, meaning that if no favorable second period shock materializes, the policy maker will devalue the currency. This option is not possible under a currency board and, hence, may provide an incentive to the policy maker to repeal the currency board more quickly.

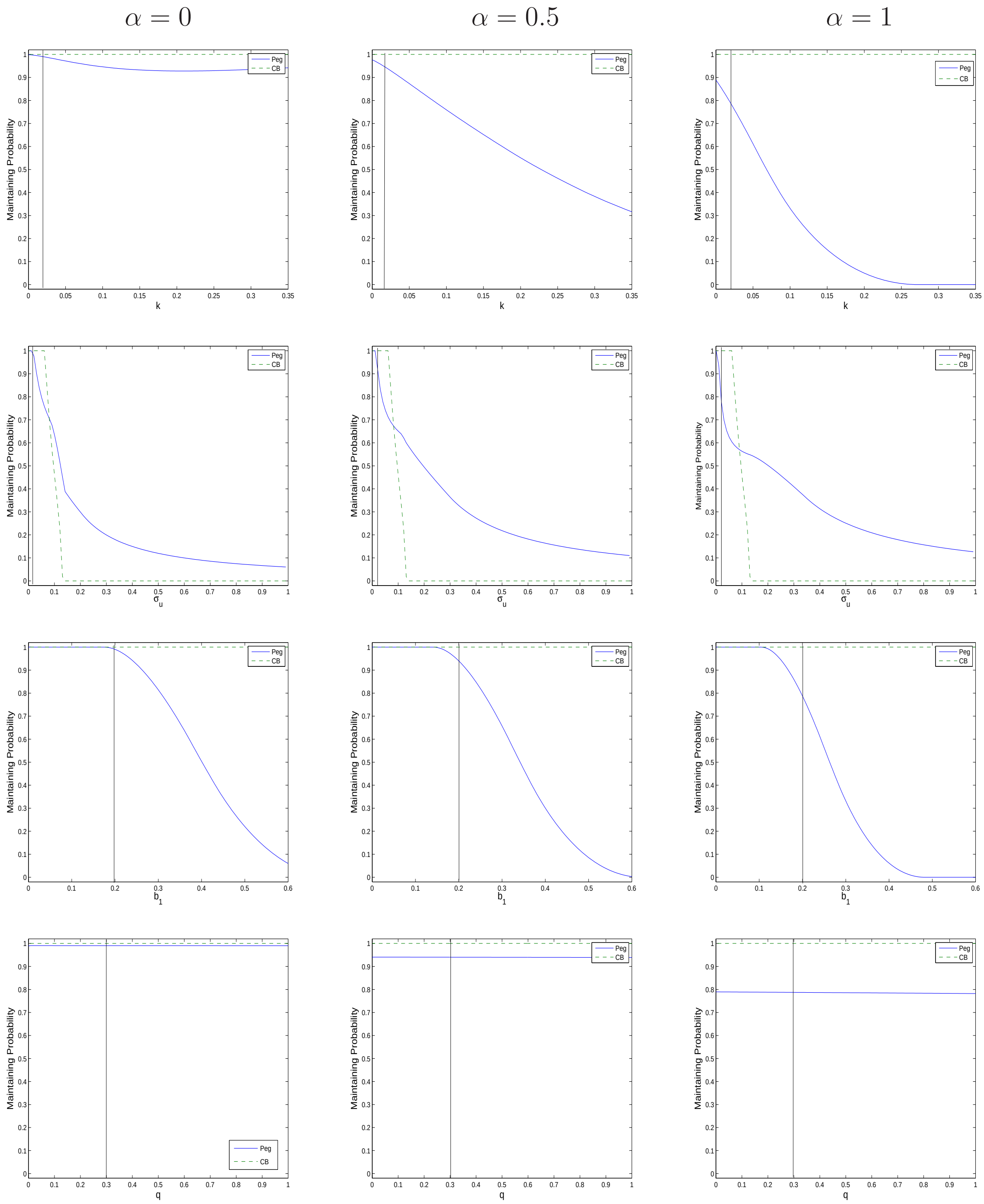
The pictures in the fourth row suggest that a rising β leads to a relative credibility advantage of a currency board. Note that β and κ are linked by the inflation equation (10) and, therefore, an increase of β is supposed to be accompanied by a falling κ. As we here vary only one parameter, we restricted the variation of β for a given κ on the interval $[0, 0.5]$. Hence, we restrict κ out of the same reason on the interval $[0.5, 1]$. By choosing these domains of κ and β, we assume that fiscal policy affects inflation, however, the main force driving inflation is still the central bank: Assume, for instance, that the government raises demand by one percent and the central bank devalues the currency by one percent at the same time, then the devaluation should have a greater effect on the inflation rate than fiscal policy has.

Unfortunately, for the rest of the parameters the probability of maintaining a currency board remains at 100% and, hence, we cannot draw further conclusions on the changes in the relative credibility of a currency board to a standard peg.

We mention here, for the sake of completeness, that the results from the graphs of scenario II stand almost in line with the results of scenario I. We abstain, therefore, from an explicit discussion.

To get further insights into the comparison of the credibility of both regimes, we use two stress scenarios. We, now, drop the assumption, which was made in section 3 and presume, instead, that a negative inherited shock hit the economy in period zero. Analogically to section 5.1, we want to examine the behavior of the maintaining probabilities of both systems, when devaluation pressure resulting from a negative inherited shock is present. The shock has to occur in period zero (and not in period one) to establish a fair setting for the comparison of the currency board and the peg system. Furthermore, we have chosen the parameter values with the intension to establish a scenario, where the policy makers' advantage under both fixed exchange-rate systems seems to be very lim-

Figure 6: Sensitivity of the Maintaining Probabilities in Scenario I



Sensitivity of the Maintaining Probabilities in Scenario I (ad figure 6)

$\alpha = 0$ | $\alpha = 0.5$ | $\alpha = 1$

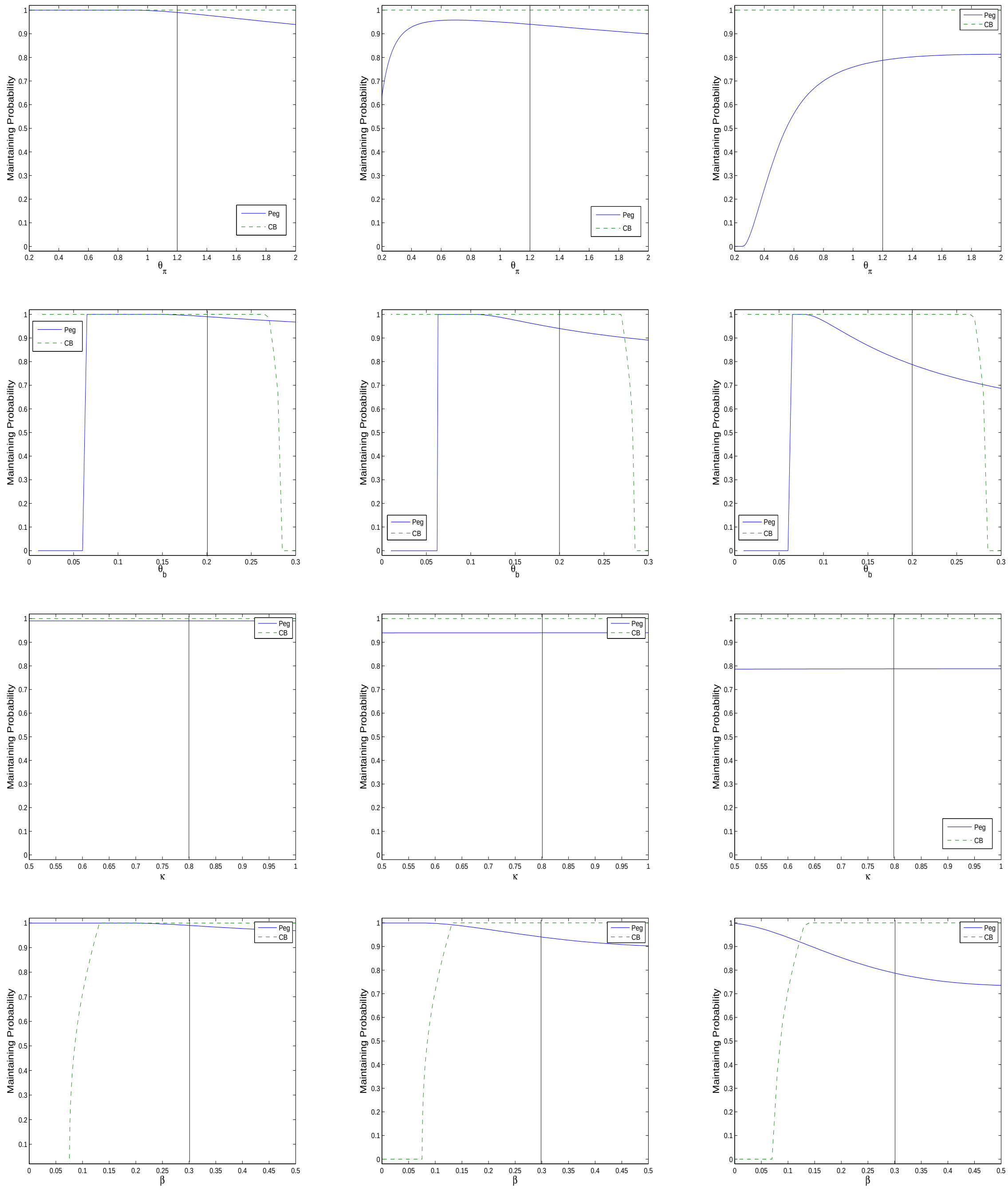


Table 6: Numerical Examples: Stress Scenarios III and IV

Parameter	Stress scenario III	Stress scenario IV
k	0.02	0.02
γ	1.00	1.00
σ_u	0.06	0.10
w	0.09	0.09
η	0.80	0.80
ϕ_1	-0.04	-0.04
b_1	0.30	0.20
θ_b	0.20	0.20
θ_π	1.50	1.50
q	0.50	0.20
κ	0.80	0.90
β	0.30	0.20
c^{CB}	0.012	0.012
$\eta\phi_0$	-0.04	-0.04

ited, i.e. besides the inherited shock from period zero, we assume a relatively high shock volatility, a relatively high κ, and a relatively small β to appear. This makes monetary policy more important as a stabilization tool, as the effect of fiscal policy was strongly reduced by the parameter choice in the scenarios III and IV and, thus, weakens the credibility of both fixed exchange-rate regimes. The parameter values for both scenarios are exhibited in table 6. The maintaining probabilities in the two scenarios are shown in table 7. In scenario III the maintaining probability of a currency board system is below 100%, and in scenario IV a repealing of the currency board is announced for any first period shock, meaning that the interval in which the currency board is defended lies completely outside the support of the shock ϕ_1 or shrinks to zero (for technical details see appendix D).

Table 7: Maintaining Probabilities for the Stress Scenarios III and IV

	Currency board	Peg ($\alpha = 0$)	Peg ($\alpha = 0.5$)	Peg ($\alpha = 1$)
Scenario III	0.9367	0.4310	0.3913	0.3128
Scenario IV	0	0.5239	0.5256	0.4843

The examination of the sensitivity of the maintaining probabilities to a parameter change is done by a discussion of the figures 7 and 8, in the following.
In both stress scenarios, the three results found in scenario I and II are confirmed from a qualitative perspective:

- an increasing shock volatility σ_u leads again to a credibility gain of the standard peg, while the absolute credibility is decreasing in both systems,
- an increasing β leads also to a credibility advantage of the currency board,
- a greater value of θ_b contributes to a credibility gain of the standard peg regime.

Fortunately, we can derive further results from the two stress scenarios: We start with the parameter k, the desired output level of the fiscal and monetary policy authorities, which determines (together with θ_π) the time inconsistency problem of monetary policy. While remembering the results from section 5.1, where we pointed out that the time inconsistency problem of monetary policy is solved completely and that at the same time the overall time inconsistency problem is reduced under a currency board system – which is not the case under a standard peg due to the existence of an escape clause in period 2 – one would suppose that a higher k leads to a relative credibility gain under a currency board system. The plots of scenario III and IV support that view, if α is greater than zero. This result comes as no surprise, because $\alpha = 0$ implies a full anticipated credibility of the private sector and in that case the time inconsistency problem of monetary policy is also solved under a peg by the definition of equation (32).

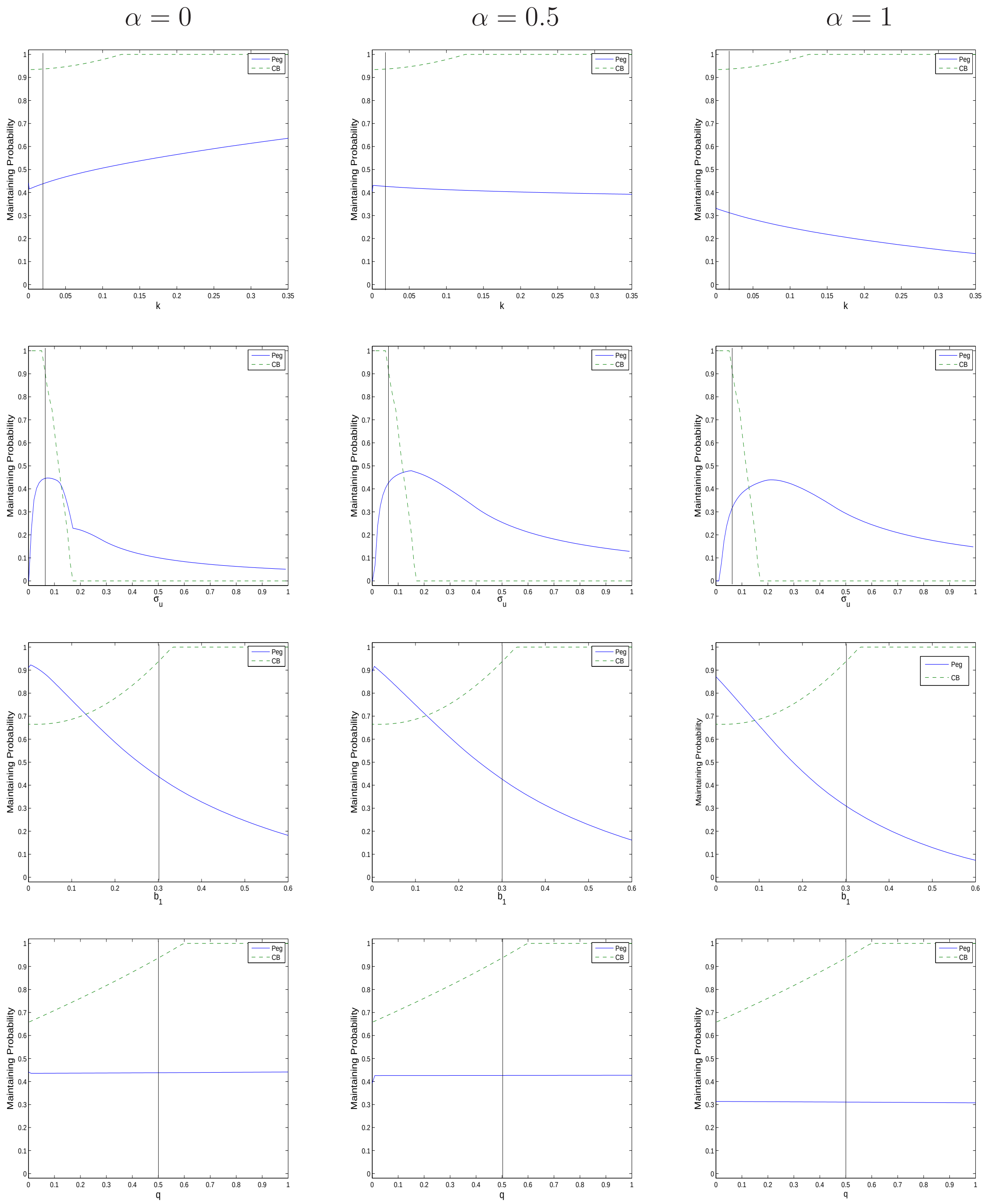
A decrease in θ_b leaves room for a more expansionary fiscal policy, which implies a more severe time inconsistency problem (of fiscal policy). As a currency board reduces the time inconsistency problem of *fiscal policy*, as mentioned before, which is not the case for a standard peg, the credibility of a currency board increases compared to a standard peg.

Scenario III further suggests that a higher inherited debt level from the first period, b_1, leads to a credibility gain of a currency board system. The explanation corresponds to that in the previous section: a higher b_1 amounts to a higher loss stemming from debts in the policy makers' loss function, if debts are not reduced in the second period. To reduce debts, the monetary authority has a higher incentive to create inflation, which at the same time aggravates the time inconsistency problem of *monetary policy*. As the time inconsistency problem of monetary policy is completely solved under a currency board system, but remains, at least partly, under a standard peg system, a higher b_1 suggests a relative credibility gain of a currency board system.

A higher fraction of foreign government debts, q, leads ceteris paribus also to a credibility gain of the currency board system. An increasing q makes the escape clause under the peg, i.e. the possibility to devalue the currency, less important, because only the fraction of government debts denominated in the home currency can be reduced. The fraction of foreign government debts may even increase in real terms.

To summarize the findings of this subsection, we can state that in the first two scenarios, which presumably accord best with reality, a currency board has (in frequent cases) an absolute credibility advantage compared to a standard peg. The argument is strengthened by the fact that we have assumed equal exit costs under both systems and have

Figure 7: Sensitivity of the Maintaining Probabilities in Scenario III



Sensitivity of the Maintaining Probabilities in Scenario III (ad figure 7)

$\alpha = 0$ $\alpha = 0.5$ $\alpha = 1$

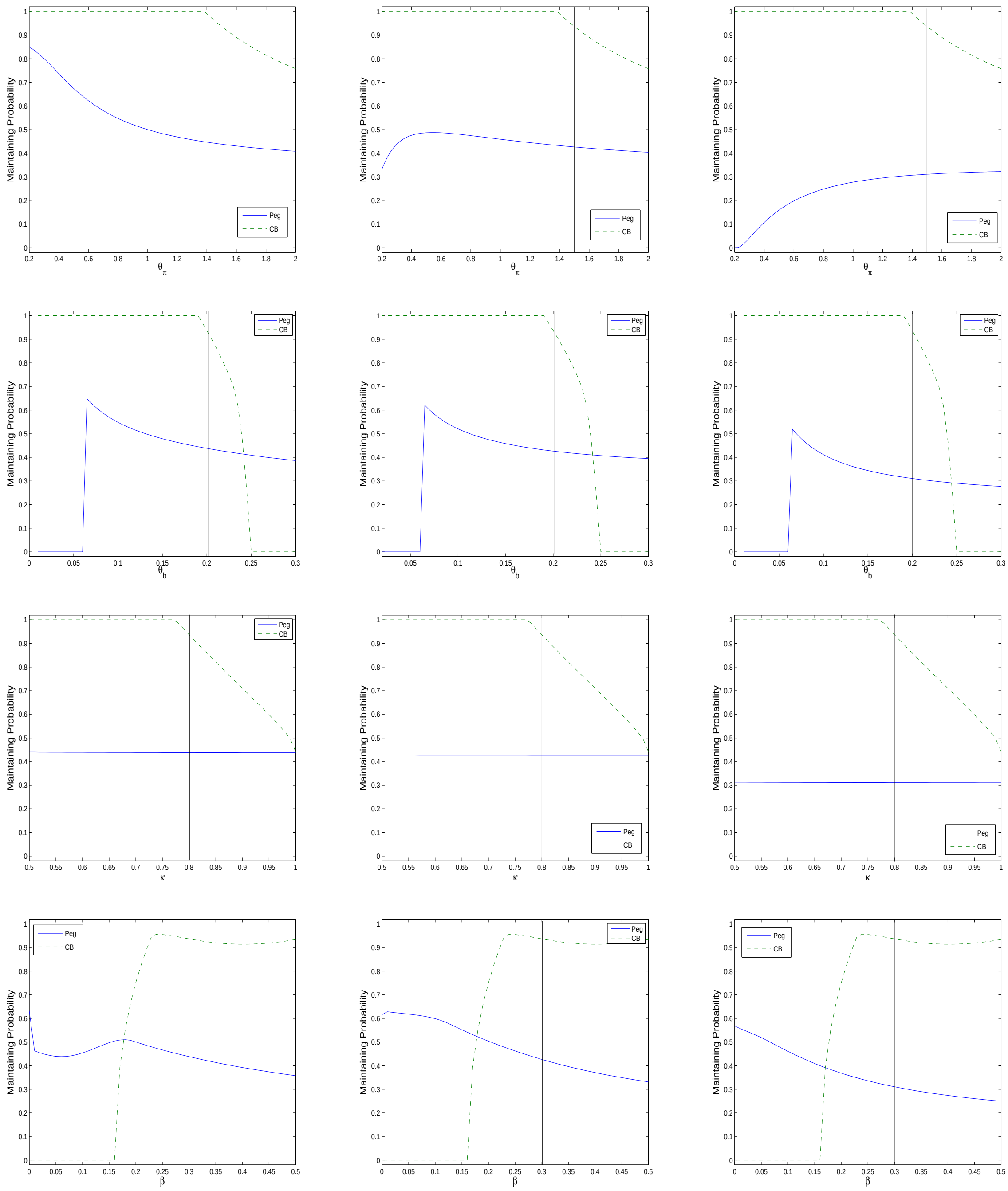
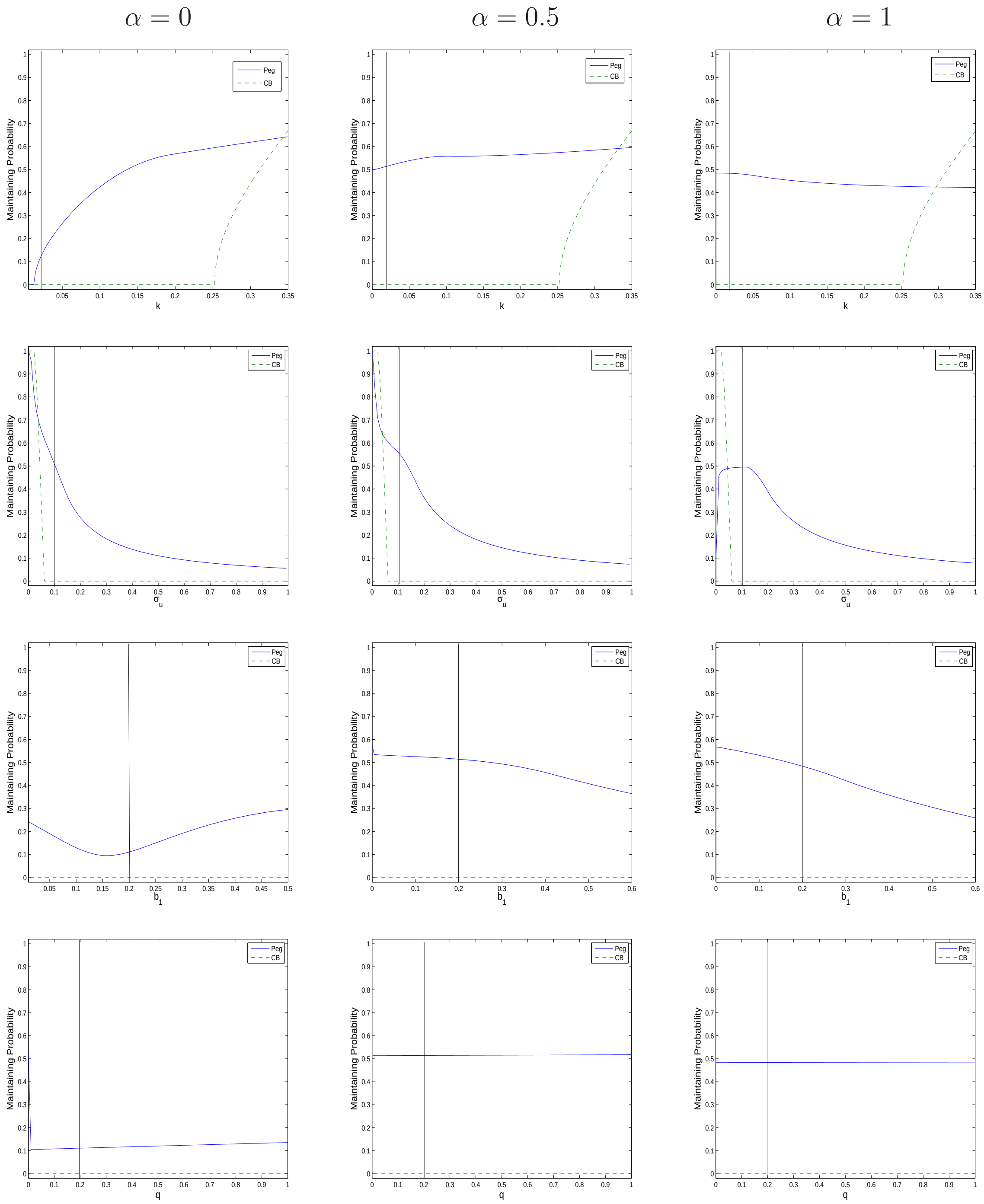
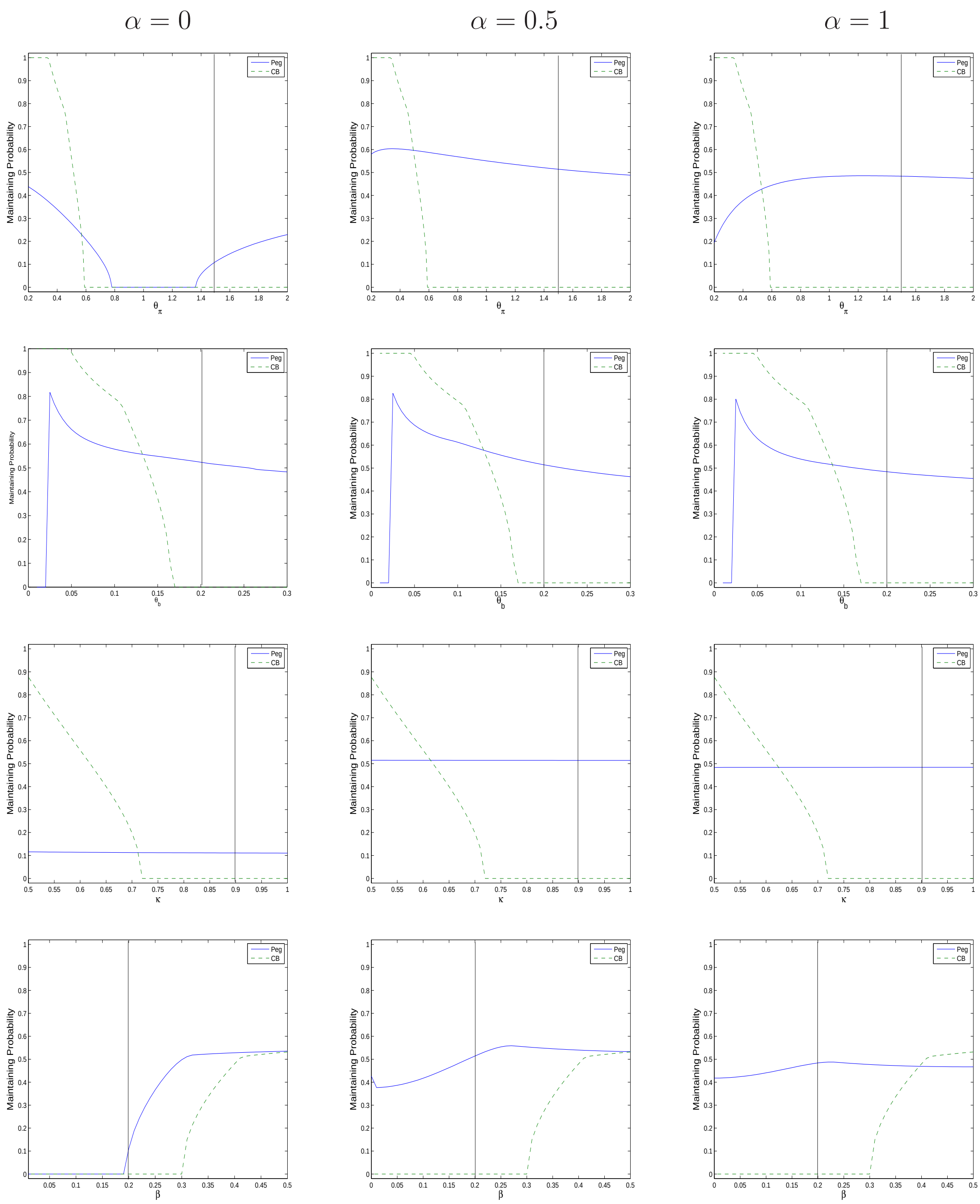


Figure 8: Sensitivity of the Maintaining Probabilities in Scenario IV



Sensitivity of the Maintaining Probabilities in Scenario IV (ad figure 8)



simulated the probability of maintaining the peg over the total range of possible shocks ϕ_1 to guarantee a fair comparison (see appendix D). This supports the empirical findings that currency board systems have proven to be stable exchange rate systems over several years, with only one abandonment (or breakdown) in Argentina.

The comparison of the credibility of a currency board and standard peg gives reason to formulate the following conclusion:

Numerical result 5. *The credibility of a currency board system and of a standard peg are measured by the probability of maintaining the system in the next period. Using this definition, the analysis of scenario I-IV states that a currency board gains a credibility advantage compared to a standard peg, when*

a) the time inconsistency problem is severe (represented by a high value k, and a small value of θ_π)

b) σ_u is low, which reduces the risk of bearing a high shock in the future period,

c) θ_b is relatively low and q relatively high, making a devaluation less necessary as a stabilization tool,

d) b_1 is large, which again leads to a more severe time inconsistency problem of monetary policy, and

e) β is relatively large and κ relatively small, again making monetary policy (=a devaluation) as a stabilization tool less important.

Result e) makes only sense from a static perspective or from a purely theoretical point of view. When discussing the stability of fixed exchange-rate regimes, a high degree of openness (κ approaching one) and no major frictions are generally seen as an essential prerequisite for a long-term stability. Otherwise, asymmetric shocks to the anchor currency or a strong accumulation of debts will make a repealing of the currency board or a realignment under the peg inevitable in the intermediate-term. To analyze such effects, a dynamic setting will be a necessary premise.

6 Conclusion

In this paper we examined two major issues, the *fiscal sustainability* and the *stability* of currency board arrangements. In section 2, we summarized empirical and theoretical work about fixed exchange-rate systems and their impact on fiscal policy. The conclusions drawn from the individual papers are quite different. Some argue that choosing a hard peg facilitates fiscal soundness, others find a contrary interrelationship, but only a few of them divided the hard peg regimes into subgroups and, thereby, focussed especially on currency boards. Two empirical studies did this and both, Fatas and Rose (2001) and Grygonite (2003), found that currency board countries actually tend to have a higher degree of fiscal discipline compared to other types of exchange rate systems.

In section 3, we introduced the basic model. The main feature of a currency board system is its anchorage by law. We state, therefore, that a currency board gains a high commitment value and cannot be abandoned surprisingly, but only if its abandonment was announced one period in advance. In contrast, the policy maker operating a standard peg regime can make use of her escape clause in every period. Thus, the time inconsistency problem of monetary policy, which means that a policy maker tries to increase the output level by creating surprise inflation through a devaluation, is solved. Though, the possibility that fiscal policy is used to create surprise inflation via an expansion of demand remains. And, therefore, the (overall) time inconsistency problem is not completely solved under a currency board either, but it is reduced.

We showed in section 4 that a currency board leads to more fiscal discipline than a peg system due to lower inflation expectations, meaning that the fiscal deficits and debts will be lower under a currency board system. The lower inflation expectations under a currency board are justified, on the one hand, by using a theoretical approach and, on the other hand, by referring to empiricism.

The examination of the stability of a currency board system was subject of section 5. First, we analyzed how the stability of a currency board changes when varying characteristic parameters by using numerical examples. The stability of a currency board is measured by the difference of the expected losses occurring when a currency board system is announced to be maintained in the next period and when it is announced to be abandoned. We showed that the stability of a currency board decreases, when a large (negative) future shock is likely to materialize due to a negative inherited shock and a high shock volatility. A currency board becomes more stable, if the time inconsistency problem is severe, as it is partially solved through the timing of the decision-making under a currency board. The stability of a currency board also increases by a higher ratio of foreign debts relative to total debts and by an increasing level of overall debt levels. A higher ratio of foreign debts makes a devaluation ceteris paribus more costly and reduces, thus, the advantage of repealing the currency board. From an empirical perspective, however, the result seems to be somewhat surprising. The reason for that may be found in not taking moral hazard aspects into account. A high level of (foreign) debts can create an incentive of the policy maker to default on its debts like for example 1999 in Ecuador and 2002 in Argentina, a behavior which is not covered in our model.

Besides that, we also showed that a currency board system has an intrinsic commitment value, which means that we find scenarios for which the currency board is maintained although no exit costs exist. This characteristic originates from the reduction of the time inconsistency problem, as aforementioned.

Second, we compare a currency board system and a standard peg system by introducing the concept of the "credibility of an exchange-rate system", which is defined as the probability that the current exchange rate system will still be in operation in the following period. We showed by using several numerical scenarios, that a standard peg gains a credibility advantage if the stabilization of future shocks is of paramount interest. This is the case if a high shock volatility exists. The result is traced back on the existence of an escape clause under a peg, meaning that a policy maker can realign its currency optimally after a large unfavorable shock hit the economy, which is not possible under a currency board. In contrast, if the time inconsistency problem is the dominant problem, a currency board gains a credibility advantage compared to a standard peg system. Furthermore, we found that a larger amount of government debts and a higher ratio of foreign debts increases the credibility of a currency board relative to a standard peg. Also, a higher impact of fiscal policy on inflation while at the same time the impact of a devaluation on inflation is decreasing makes the exchange rate policy less important as a stabilization tool and, hence, raises the credibility of a currency board system relatively to the credibility of a standard peg.

To get insights into the debt evolution and the stability of a currency board system over an intermediate time-horizon, we focus on an enhancement of the model to more periods in our future research. However, as the parametrization makes the model already woefully complicated in the two-period setting, further restrictive assumptions would be necessary.

An additional interesting modification of the model would be to incorporate nominal interest rates endogenously: If debts are accumulated, private creditors would increase the level of the rate of returns on government bonds to be willing to accept further debts due to the demand of a higher risk premia. We suppose that this would also affect the stability and credibility of a currency board system. In this context a consideration of borrowing constraints would be meaningful, too.

A Calculations for a Fixed Exchange Rate System

In the following part of the appendix, we determine optimal fiscal and monetary policy under a fixed exchange-rate system. At first, we make the assumption that expected inflation is treated as given. The results of the calculations are used in section 4.1 and in section 5. After that, we reformulate the loss function and determine the rational expectations equilibrium for the case of the exchange rate peg being defended with a probability of one.

A.1 Optimization with Exogenous π_2^e

The optimization problem of the policy maker is given by

$$\begin{aligned}\max_{y_2,\pi_2,b_2,g_2} \mathcal{L}_2 &= \frac{1}{2}(y_2-k)^2+\frac{1}{2}\theta_\pi\pi_2^2+\frac{1}{2}\theta_b b_2^2 \\ &\quad +\lambda_1(y_2-\gamma(\pi_2-\pi_2^e)-wg_2) \\ &\quad +\lambda_2(\pi_2-\phi_2-\beta g_2) \\ &\quad +\lambda_3(b_2-b_1(1-\pi_2)-g_2)\ . \end{aligned} \tag{33}$$

The first order conditions are

$$\frac{\partial\mathcal{L}_2}{\partial y_2} = (y_2-k)+\lambda_1=0 \tag{34}$$

$$\frac{\partial\mathcal{L}_2}{\partial \pi_2} = \theta_\pi\pi_2-\gamma\lambda_1+\lambda_2+\lambda_3 b_1=0 \tag{35}$$

$$\frac{\partial\mathcal{L}_2}{\partial b_2} = \theta_b b_2+\lambda_3=0 \tag{36}$$

$$\frac{\partial\mathcal{L}_2}{\partial g_2} = w\lambda_1+\beta\lambda_2+\lambda_3=0\ . \tag{37}$$

Combining equations (34), (36) and (37) yields

$$\lambda_2=-\frac{w\lambda_1}{\beta}-\frac{\lambda_3}{\beta}=\frac{\theta_b b_2}{\beta}+\frac{w}{\beta}(y_2-k)\ . \tag{38}$$

By inserting (34), (36) and (38) into (35), we obtain

$$\begin{aligned}\theta\pi_2 &= k\frac{\gamma\beta+w}{\beta}-y_2\frac{\gamma\beta+w}{\beta}+\theta_b b_2\frac{\beta b_1-1}{\beta} \\ \Leftrightarrow y_2 &= -\frac{\theta_\pi\beta}{\gamma\beta+w}\pi_2+\theta_b b_2\frac{\beta b_1-1}{\gamma\beta+w}+k\ . \end{aligned} \tag{39}$$

Restriction 3 (=debt equation) solved for g_2 yields

$$g_2=b_2+b_1\pi_2-b_1. \tag{40}$$

Inserting into restriction 1 (=output equation) leads to

$$\begin{aligned} y_2 &= \gamma(\pi_2-\pi_2^e)+wg_2=\gamma\pi_2-\gamma\pi_2^e+wb_2+wb_1\pi_2-wb_1 \\ &= \pi_2(\gamma+wb_1)+wb_2-wb_1-\gamma\pi_2^e. \end{aligned} \tag{41}$$

Combining (39) and (41) yields

$$\begin{aligned}\theta_\pi \pi_2 &= k\frac{\gamma\beta + w}{\beta} - \frac{\gamma\beta + w}{\beta}(\pi_2(\gamma + wb_1) + wb_2 - wb_1 - \gamma\pi_2^e) \\ &\quad +\theta_b b_2 \frac{\beta b_1 - 1}{\beta}\end{aligned} \tag{42}$$

Some further manipulations lead to

$$\pi_2 = -\frac{\theta_b(1-\beta b_1) + w(\gamma\beta + w)}{(\gamma + wb_1)(\gamma\beta + w) + \theta_\pi \beta} b_2 + \frac{(k + \gamma\pi_2^e + wb_1)(\gamma\beta + w)}{(\gamma + wb_1)(\gamma\beta + w) + \theta_\pi\beta} . \tag{43}$$

Restriction 2 (=inflation equation) combined with restriction 3 (=debt equation) gives

$$\pi_2 = \frac{\beta}{1-\beta b_1} b_2 + \frac{\phi_2 - \beta b_1}{1 - \beta b_1} . \tag{44}$$

Setting (43) equal to (44) leads to the optimum value of second period debts (for a given π_2^e) which equals

$$b_2^* = \frac{(k + \gamma\pi_2^e + wb_1)(\gamma\beta + w)(1-\beta b_1) - (\phi_2 - \beta b_1)\big((\gamma + wb_1)(\gamma\beta + w) + \theta_\pi\beta\big)}{(\gamma\beta + w)^2 + \theta_\pi\beta^2 + \theta_b(1-\beta b_1)^2} . \tag{45}$$

For a better exposition and to simplify further calculations, we define $A := w + \gamma\beta$ and $B := (1 - \beta b_1)$. Note that from the domain of parameters used here $A > 0$ and $B > 0$ is obvious. Therefore, we can rewrite b_2^* as

$$b_2^* = \frac{(k + \gamma\pi_2^e + wb_1)AB}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} - \frac{(\phi_2 - \beta b_1)(\theta_\pi\beta + A(\gamma + wb_1))}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} . \tag{46}$$

The optimal second period inflation rate and the optimal output y_2 are given by

$$\begin{aligned}\pi_2^* &= \frac{\phi_2 - \beta b_1}{B} + \frac{\beta}{B} b_2^* \\ &= \frac{\beta A(k + \gamma\pi_2^e) + \phi_2(\theta_b B + wA) - \theta_b\beta B b_1}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} ,\end{aligned} \tag{47}$$

$$\begin{aligned}y_2^* &= k - \theta_b b_2^* \frac{B}{A} - \theta_\pi \pi_2^* \frac{\beta}{A} \\ &= \frac{kA^2 - \theta_b b_1 AB - \gamma\pi_2^e(\theta_b B^2 + \theta_\pi\beta^2) + \phi_2(\theta_b B(\gamma + wb_1) - \theta_\pi w\beta)}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} .\end{aligned} \tag{48}$$

To reach the optimum, the policy maker chooses a fiscal deficit of

$$\begin{aligned}g_2^* &= b_2^* + b_1\pi_2^* - b_1 \\ &= \frac{(k + \pi_2^e)A + \phi_2(\theta_b B - \theta_\pi\beta + A(w + \gamma + wb_1)) + b_1(A(\gamma\beta - 1) + w - \theta_b B)}{\theta_b B^2 + A^2 + \theta_\pi\beta^2} .\end{aligned}$$

The derivatives of optimal second period output, inflation, debt, and of the policy instrument g_2 for π_2^e equals:

$$
\begin{aligned}
\frac{\partial b_2}{\partial \pi_2^e} &= \frac{\gamma(\gamma\beta + w)(1-\beta b_1)}{(\gamma\beta+w)^2 + \beta^2\theta_\pi + \theta_b(1-\beta b_1)^2} > 0 \quad \text{for } \beta b_1 < 1 && (49)\\
\frac{\partial \pi_2}{\partial \pi_2^e} &= \frac{\gamma\beta(\gamma\beta + w)}{(\gamma\beta+w)^2 + \beta^2\theta_\pi + \theta_b(1-\beta b_1)^2} > 0 && (50)\\
\frac{\partial g_2}{\partial \pi_2^e} &= \frac{\gamma\beta + w}{(\gamma\beta+w)^2 + \beta^2\theta_\pi + \theta_b(1-\beta b_1)^2} > 0 && (51)\\
\frac{\partial y_2}{\partial \pi_2^e} &= -\frac{\gamma(\theta_b B^2 + \theta_\pi\beta^2)}{(\gamma\beta+w)^2 + \beta^2\theta_\pi + \theta_b(1-\beta b_1)^2} < 0\ . && (52)
\end{aligned}
$$

A.2 Reformulation of the Loss Function as a Function of π_2

For a better handling in section 5, we rewrite the loss function by using the calculations of the first section of appendix A (for a given π_2^e). From equation 41, we have

$$y_2 = \pi_2(\gamma + wb_1) + wb_2 - wb_1 - \gamma\pi_2^e\ . \qquad (53)$$

Solving (44) for b_2 yields

$$b_2 = \frac{B}{\beta}\pi_2 - \frac{\phi_2 - \beta b_1}{\beta} = \frac{1-\beta b_1}{\beta}\pi_2 - \frac{\phi_2}{\beta} + b_1\ . \qquad (54)$$

Inserting (54) into (53) leads to

$$y_2 = \pi_2\frac{w+\gamma\beta}{\beta} - \frac{w}{\beta}\phi_2 - \gamma\pi_2^e\ . \qquad (55)$$

Plugging (54) and (55) into the loss function, we obtain

$$
\begin{aligned}
2\cdot L_2^{CB}(\pi_2) &= \left(\pi_2\frac{w+\gamma\beta}{\beta} - \frac{w}{\beta}\phi_2 - \gamma\pi_2^e - k\right)^2 + \theta_\pi\pi_2^2\\
&\quad +\theta_b\left(\frac{1-\beta b_1}{\beta}\pi_2 - \frac{\phi_2}{\beta} + b_1\right)^2\ . \qquad (56)
\end{aligned}
$$

A.3 Rational Expectations Equilibrium

We assume that the private sector has rational expectations on inflation. Then, the following condition holds:

$$\pi_2^e = E(\pi_2) = \frac{\beta Ak + \eta\phi_1(\theta_b B + wA) - \theta_b\beta b_1 B}{\theta_b B^2 + wA + \theta_\pi\beta^2}\ . \qquad (57)$$

Inserting (57) into equation (47) yields the rational expectation equilibrium value, given by[26]

$$\pi_2^{**} = \frac{\beta Ak + \eta\phi_1(\theta_b B + wA) - \theta_b\beta b_1 B}{\theta_b B^2 + wA + \theta_\pi\beta^2} + u_2\frac{\theta_b B + wA}{\theta_b B^2 + A^2 + \theta_\pi\beta^2}\ . \qquad (58)$$

[26]Rational expectations equilibrium values are denoted by the superscript "**".

The equilibrium value for b_2 is obtained by plugging (58) into equation (54):

$$\begin{aligned} b_2^{**} &= \pi_2^{**}\frac{B}{\beta} - \frac{\phi_2}{\beta} + b_1 \\ &= \frac{B(\beta Ak + \eta\phi_1(\theta_b B + wA) - \theta_b b_1 \beta B)}{\beta(\theta_b B^2 + wA + \theta_\pi \beta^2)} + b_1 - u_2 \frac{A(\gamma + wb_1)}{\theta_b B^2 + A^2 + \theta_\pi \beta^2} \ , \end{aligned} \quad (59)$$

and y_2 can be obtained by plugging (58) into (55)

$$y_2^{**} = w\pi_2^{**} + \gamma u_2 \frac{\theta_b B + wA}{\theta_b B^2 + A^2 + \theta_\pi \beta^2} - \frac{w}{\beta}\phi_2 \ . \quad (60)$$

The rational expectations equilibrium is used in the sections 4.2 and in section 5. Note that we, of course, can calculate the optimal size of government expenditure (=fiscal deficit) g_2 for the rational expectations equilibrium, too.

B Calculation for a Flexible Exchange Rate System

We, here, derive optimal fiscal and monetary policy under flexible exchange rates. At the beginning of this section, we make again the assumption that expected inflation is exogenous. The results are used in section 4.1. Thereafter, we reformulate the loss function and determine the rational expectations equilibrium.

B.1 Optimization with an Exogenous π_2^e and an Exogenous Ratio of Foreign Debts q

Optimization problem of the policy maker:

$$\begin{aligned} \max_{y_2,\pi_2,b_2,g_2,e_2} \mathcal{L}_2 &= \frac{1}{2}(y_2 - k)^2 + \frac{1}{2}\theta_\pi \pi_2^2 + \frac{1}{2}\theta_b b_2^2 \\ &\quad + \lambda_1(y_2 - \gamma(\pi_2 - \pi_2^e) - wg_2) \\ &\quad + \lambda_2(\pi_2 - \phi_2 - \kappa e_2 - \beta g_2) \\ &\quad + \lambda_3(b_2 - b_1(1 + qe_2 - \pi_2) - g_2) \ , \end{aligned} \quad (61)$$

where e_2 and g_2 are the policy instruments to reach the output-, inflation- and debt-goal. The first order conditions are

$$\frac{\partial \mathcal{L}_2}{\partial y_2} = (y_2 - k) + \lambda_1 \Leftrightarrow \lambda_1 = k - y_2 = 0 \quad (62)$$

$$\frac{\partial \mathcal{L}_2}{\partial \pi_2} = \theta_\pi \pi_2 - \gamma\lambda_1 + \lambda_2 + \lambda_3 b_1 = 0 \quad (63)$$

$$\frac{\partial \mathcal{L}_2}{\partial b_2} = \theta_b b_2 + \lambda_3 = 0 \Leftrightarrow \lambda_3 = -\theta_b b_2 \quad (64)$$

$$\frac{\partial \mathcal{L}_2}{\partial g_2} = -w\lambda_1 - \beta\lambda_2 - \lambda_3 = 0 \quad (65)$$

$$\frac{\partial \mathcal{L}_2}{\partial e_2} = -\kappa\lambda_2 - b_1 q\lambda_3 = 0 \ . \quad (66)$$

Combining (66) and (64) yields

$$\lambda_2 \;=\; -\frac{b_1 q}{\kappa}\lambda_3 = \frac{q b_1 \theta_b b_2}{\kappa} \; . \tag{67}$$

Plugging (67) and (62) into (65) leads to

$$\lambda_1 = -\frac{\beta}{w}\lambda_2 - \frac{\lambda_3}{w} = -\frac{q b_1 \beta \theta_b b_2}{wk} + \frac{\theta_b b_2}{w} = \theta_b b_2 \frac{\kappa - q\beta b_1}{w\kappa} \; . \tag{68}$$

Using (64), (67), (68) and (63), we obtain

$$\pi_2 \;=\; \frac{\theta_b b_2}{\theta_\pi}\frac{\gamma(\kappa - q\beta b_1) - b_1 w(q-\kappa)}{w\kappa} \; . \tag{69}$$

The first order condition with respect to λ_3 solved for g_2 equals

$$g_2 = b_2 - b_1(1 + q e_2 - \pi_2) = b_2 - b_1 q e_2 - b_1 + b_1 \pi_2 \; . \tag{70}$$

The first order condition with respect to λ_2 solved for e_2 yields

$$\begin{aligned} \pi_2 &= \phi_2 + \kappa e_2 + \beta g_2 \\ \Leftrightarrow e_2 &= \frac{1}{\kappa}(\pi_2 - \phi_2 - \beta g_2). \end{aligned} \tag{71}$$

Combining (70) and (71) leads to

$$g_2 = \frac{b_2 \kappa}{\kappa - b_1 q \beta} + \frac{b_1(k-q)}{\kappa - b_1 q\beta}\pi_2 + \frac{b_1 q}{\kappa - b_1 q \beta}\phi_2 - \frac{b_1 \kappa}{\kappa - b_1 q\beta} \; . \tag{72}$$

Using (62) and (68) yields

$$y_2 = k - \theta_b b_2 \frac{\kappa - q\beta b_1}{w\kappa} \; . \tag{73}$$

Inserting (71) into the output equation (first order condition with respect to λ_1), we obtain

$$y_2 = \pi_2 \frac{\gamma(\kappa - b_1 q\beta) + w b_1(\kappa - q)}{\kappa - b_1 q\beta} + \frac{w}{\kappa - b_1 q\beta}(\kappa b_2 + q b_1 \phi_2 - b_1 \kappa) - \gamma \pi_2^e \; . \tag{74}$$

Using (73) with (74) yields

$$\pi_2 = \frac{(k + \gamma\pi_2^e)(\kappa - b_1 q\beta) - w b_1(q\phi_2 - \kappa)}{\gamma(\kappa - b_1 q\beta) + w b_1(\kappa - q)} - \frac{\theta_b(\kappa - b_1 q\beta)^2 + (w\kappa)^2}{w\kappa(\gamma(\kappa - b_1 q\beta) + w b_1(\kappa - q))} b_2 \; . \tag{75}$$

By combining (69) and (75), we obtain the optimal second period debt level b_2 as a function of inflation expectations of the private sector π_2^e by[27]

$$b_2^f = \frac{\theta_\pi w\kappa(\kappa - b_1 q\beta)(k + \gamma\pi_2^e) + \theta_\pi w^2 b_1 \kappa(\kappa - q\phi_2)}{\theta_b(\gamma(\kappa - b_1 q\beta) + b_1(\kappa - q))^2 + \theta_\pi\theta_b(\kappa - b_1 q\beta)^2 + \theta_\pi(w\kappa)^2} \; . \tag{76}$$

[27] We denote the equilibrium values in the free float case by a superscript f, henceforth.

We define $E := \kappa - q\beta b_1$ and $F := wb_1(\kappa - q)$. E and F may both have either sign, mainly depending on the size of foreign debts q and the openness parameter κ. From an empirical perspective, however, a prerequisite for a stable exchange rate is a highly open economy, which guarantees the flexibility necessary to offset unfavorable shocks (this means κ is close to one); at the same time, a credibly stable exchange rate is characterized by the fact that creditors trust more in domestic debts, which contributes to a small q. If this holds for the considered economy, E and F are positive. Using the abbreviations, we can rewrite (76) as

$$b_2^f = \frac{E(k+\gamma\pi_2^e)\theta_\pi w\kappa + \theta_\pi w^2 b_1 \kappa(\kappa - q\phi_2)}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} \ . \tag{77}$$

The optimal value for inflation is calculated from (69):

$$\begin{aligned} \pi_2^f &= b_2^f \frac{\theta_b}{\theta_\pi} \frac{\gamma(\kappa - b_1 q\beta) + wb_1(\kappa - q)}{w\kappa} \\ &= \frac{\theta_b(\gamma E + F)\left[E(k+\gamma\pi_2^e) + wb_1(\kappa - q\phi_2)\right]}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} \ ; \end{aligned} \tag{78}$$

and optimal output is derived from (73) as

$$\begin{aligned} y_2^f &= k - \theta_b b_2^f \frac{E}{w\kappa} \\ &= k - \frac{\theta_b E\left[(k+\gamma\pi_2^e)\theta_\pi E + \theta_\pi w b_1(\kappa - q\phi_2)\right]}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} \ . \end{aligned} \tag{79}$$

Combining the k-terms yields

$$k\left[\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2 - \theta_b\theta_\pi E^2\right] = k(\theta_b(\gamma E + F)^2 + \theta_\pi(w\kappa)^2) \ . \tag{80}$$

Inserting in (79) leads to

$$y_2^f = \frac{k(\theta_b(\gamma E + F)^2 + \theta_\pi(w\kappa)^2) - \theta_b\theta_\pi E^2\gamma\pi_2^e - \theta_b\theta_\pi E w b_1(\kappa - q\phi_2)}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} \ . \tag{81}$$

B.2 Reformulation of the Loss Function as a Function of π_2

To simplify the calculations in section 5 and appendix D, we rewrite the loss function of a flexible exchange rate system. As shocks are perfectly offset in this setting, output and debts can be expressed as a multiple of π_2^f. Therefore, the loss function has the simple form

$$\begin{aligned} 2\cdot L_2 &= (y_2 - k)^2 + \theta_\pi(\pi_2^f)^2 + \theta_b b_2^2 \\ &= (\pi_2^f)^2\left(\theta_\pi + \theta_\pi^2\left[\frac{(\kappa - q\beta b_1)^2 + (\theta_b w\kappa)^2}{(\gamma(\kappa - q\beta b_1) + wb_1(\kappa - q))^2}\right]\right) \ . \end{aligned} \tag{82}$$

B.3 Calculation of the Rational Expectations Equilibrium

Assuming rational expectations of inflation, we have

$$\pi_2^{e,f} = E(\pi_2^f) = \frac{\theta_b(\gamma E + F)\left[E(k + \gamma\pi_2^{e,f}) + wb_1(\kappa - q\eta\phi_1)\right]}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} \tag{83}$$

$$\begin{aligned}
\Leftrightarrow \quad & \pi_2^{e,f}\left(1 - \frac{\theta_b(\gamma E + F)\gamma E}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2}\right) \\
\Leftrightarrow \pi_2^{e,f} \quad &= \quad \frac{\theta_b(\gamma E + F)\left[Ek + wb_1(\kappa - q\eta\phi_1)\right]}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2 - \theta_b(\gamma E - F)E\gamma} \\
\Leftrightarrow \pi_2^{e,f} \quad &= \quad \frac{\theta_b(\gamma E + F)\left[Ek + wb_1(\kappa - q\eta\phi_1)\right]}{\theta_b F(F + \gamma E) + \theta_\pi(w\kappa)^2 + \theta_\pi\theta_b E^2} \ .
\end{aligned} \tag{84}$$

To check the correctness of the result, we plug (84) into (78):

$$\begin{aligned}
\pi_2^{**f} \quad &= \quad \frac{\theta_b(\gamma E + F)\left[Ek + wb_1(\kappa - q\phi_2)\right]}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} + \frac{\theta_b(\gamma E + F)\gamma E}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} \\
& \cdot \frac{\theta_b(\gamma E + F)\left[Ek + wb_1(\kappa - q\eta\phi_1)\right]}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2 - \theta_b(\gamma E + F)E\gamma} \\
&= \quad \frac{\theta_b(\gamma E + F)\left[Ek + wb_1(\kappa - q\eta\phi_1)\right]}{\theta_b F(F + \gamma E) + \theta_\pi(w\kappa)^2 + \theta_\pi\theta_b E^2} \\
& - \frac{\theta_b(\gamma E + F)wb_1 q u_2}{\theta_b(\gamma E + F)^2 + \theta_\pi\theta_b E^2 + \theta_\pi(w\kappa)^2} \ .
\end{aligned} \tag{85}$$

C Determination of the Threshold for Maintaining or Leaving the Currency Board

The rational expectation equilibrium values for y_2, π_2, and b_2 were depicted in section 4.1 (currency board) and part B (free float) and are used in the following.

The characteristics of a currency board that its abandonment must be announced in advance leads to the following maintaining condition:

$$E(L_2^f) + c^{CB} \geq E(L_2^{CB}) \ . \tag{86}$$

Note that the exit costs c^{CB} are given exogenously. The condition means that the policy maker compares the expected loss which would occur if she decides to maintain the currency board with the situation in which she decides to abolish the currency board and chooses the optimal exchange rate freely and optimally. The loss in the latter case, of course, corresponds to the expected loss under a free float. The comparison is done in the following.

We again make use of the following abbreviations, which were introduced in the appendices A and B:

$$A = w + \gamma\beta > 0; \quad B = 1 - \beta b_1 > 0; \quad F = wb_1(\kappa - q); \quad E = \kappa - q\beta b_1 \ .$$

Note that when referring to the domains of the particular parameters E and F the appearance of negative values cannot be excluded per se.

C.1 Determination of the Expected Loss under a Currency Board

Using equation (56), we calculate the loss under a currency board when inserting the rational expectations equilibrium values:

$$
\begin{aligned}
L_2^{cb}(\pi_2) &= \left(\pi_2 \frac{w+\gamma\beta}{\beta} - \frac{w}{\beta}\phi_2 - \gamma\pi_2^e - k\right)^2 + \theta_\pi \pi_2^2 \\
&\quad + \theta_b \left(\frac{1-\beta b_1}{\beta}\pi_2 - \frac{\phi_2}{\beta} + b_1\right)^2 . \qquad (87)
\end{aligned}
$$

We define $D := \theta_b B^2 + A^2 + \theta_\pi \beta^2$ and $\tilde{D} := \theta_b B^2 + wA + \theta_\pi \beta^2$. Both D and $\tilde{D}$ are obviously strictly positive. We use these abbreviations in the following and refer to appendix B, where

$$
\gamma(\pi_2 - \pi_2^e) = u_2 \frac{\theta_b B + wA}{D} , \qquad (88)
$$

and

$$
\begin{aligned}
\frac{w}{\beta}(\pi_2 - \phi_2) &= \frac{w}{\beta}(\pi_2 - \eta\phi_1 - u_2) \\
&= \frac{w}{\beta} \frac{\beta A k + \eta\phi_1(\theta_b B + wA - \theta_b B^2 - wA - \theta_\pi\beta^2) - \theta_b \beta b_1 B}{\tilde{D}} \\
&\quad + u_2 \frac{w}{\beta} \frac{\theta_b B + wA - \theta_b B^2 - A^2 - \theta_\pi \beta^2}{D} \\
&= w \frac{Ak + \eta\phi_1(\theta_b b_1 B - \theta_\pi \beta) - \theta_b b_1 B}{\tilde{D}} \\
&\quad + w u_2 \frac{\theta_b b_1 B - \gamma A - \theta_\pi \beta}{D} . \qquad (89)
\end{aligned}
$$

Combining both parts and adding "$-k$", we can rewrite the output goal in the loss function as

$$
\begin{aligned}
(y_2 - k)^2 &= \Bigg(w \frac{Ak + \eta\phi_1(\theta_b b_1 B - \theta_\pi\beta) - \theta_b b_1 B}{\tilde{D}} - k \\
&\quad + u_2 \frac{wB\theta_b b_1 - \gamma w A - w\theta_\pi \beta + \theta_b B + wA}{D} \Bigg)^2 \\
&= \Bigg(k \underbrace{\left[\frac{wA - \tilde{D}}{\tilde{D}}\right]}_{=:Q_1} + \eta\phi_1 \underbrace{\left[\frac{\theta_b b_1 B - \theta_\pi \beta}{\tilde{D}}\right]}_{=:Q_2} \\
&\quad + u_2 \underbrace{\left[\frac{\theta_b B(w b_1 + 1) + wA(1-\gamma) - w\theta_\pi\beta}{D}\right]}_{=:Q_3} + \underbrace{\left[-\frac{\theta_b b_1 B}{\tilde{D}}\right]}_{=:Q_4} \Bigg)^2 . \qquad (90)
\end{aligned}
$$

The inflation goal $\theta_\pi \pi_2^2$ can be rewritten by using equation (47) as

$$\theta_\pi \pi_2^2 = \theta_\pi \left(k \underbrace{\left[\frac{\beta A}{\tilde{D}}\right]}_{=:Q_5} + \eta\phi_1 \underbrace{\left[\frac{\theta_b B + wA}{\tilde{D}}\right]}_{=:Q_6} + u_2 \underbrace{\left[\frac{\theta_b B + wA}{D}\right]}_{=:Q_7} + \underbrace{\left[\frac{-\theta_b b_1 \beta B}{\tilde{D}}\right]}_{=:Q_8} \right)^2 . \qquad (91)$$

The third term of the loss function $\theta_b b^2$ can be transformed into

$$\begin{aligned}
\theta_b b_2^2 &= \theta_b \left[\frac{1}{\beta}(B\pi_2 - \eta\phi_1 - u_2) + b_1\right]^2 \\
&= \theta_b \Bigg(\frac{\beta ABk + \eta\phi_1(\theta_b B^2 + wAB - \theta_b B^2 - wA - \theta_\pi \beta^2) - \theta_b \beta b_1 B^2}{\beta \tilde{D}} \\
&\quad + u_2 \frac{\theta_b B^2 + wAB - \theta_b B^2 - A^2 - \theta_\pi \beta^2}{\beta D} + b_1 \Bigg)^2 \\
&= \theta_b \left(\frac{ABk + \eta\phi_1(wb_1 A - \theta_\pi \beta) - \theta_b b_1 B^2}{\tilde{D}} + u_2 \frac{-A(wb_1 + \gamma) - \theta_\pi \beta^2}{D} + b_1 \right)^2 \\
&= \theta_b \Bigg(k \underbrace{\left[\frac{AB}{\tilde{D}}\right]}_{=:Q_9} + \eta\phi_1 \underbrace{\left[\frac{wAb_1 - \theta_\pi \beta}{\tilde{D}}\right]}_{=:Q_{10}} + u_2 \underbrace{\left[\frac{-A(wb_1 + \gamma) - \theta_\pi \beta}{D}\right]}_{=:Q_{11}} \\
&\quad + \underbrace{\left[b_1 - \frac{\theta_b b_1 B^2}{\tilde{D}}\right]}_{=:Q_{12}} \Bigg)^2 . \qquad (92)
\end{aligned}$$

By using the abbreviations $Q_1, \ldots, Q_{12}$ in the loss function, we obtain

$$\begin{aligned}
L_2^{cboard} &= k^2 Q_1^2 + (\eta\phi)^2 Q_2^2 + u_2^2 Q_3^2 + Q_4^2 + 2k\eta\phi_1 Q_1 Q_2 + 2ku_2 Q_1 Q_3 + 2kQ_1 Q_4 \\
&\quad + 2\eta\phi_1 u_2 Q_2 Q_3 + 2\eta\phi_1 Q_2 Q_4 + 2u_2 Q_3 Q_4 \\
&\quad + \theta_\pi (k^2 Q_5^2 + (\eta\phi_1)^2 Q_6^2 + u_2^2 Q_7^2 + Q_8^2 + 2k\eta\phi_1 Q_5 Q_6 + 2ku_2 Q_5 Q_7 + 2kQ_5 Q_8 \\
&\quad + 2\eta\phi_1 u_2 Q_6 Q_7 + 2\eta\phi_1 Q_6 Q_8 + 2u_2 Q_7 Q_8) \\
&\quad + \theta_b (k^2 Q_9^2 + (\eta\phi_1)^2 Q_{10}^2 + u_2^2 Q_{11}^2 + Q_{12}^2 + 2k\eta\phi_1 Q_9 Q_{10} + 2ku_2 Q_9 Q_{11} + 2kQ_9 Q_{12} \\
&\quad + 2\eta\phi_1 u_2 Q_{10} Q_{11} + 2\eta\phi_1 Q_{10} Q_{12} + 2u_2 Q_{11} Q_{12}) . \qquad (93)
\end{aligned}$$

The expected value of L_2, by noticing that $E(u_2) = 0$ and $E(u_2^2) = \sigma_u^2$, equals

$$\begin{aligned}
E(L_2^{cboard}) &= k^2 Q_1^2 + (\eta\phi)^2 Q_2^2 + \sigma_u^2 Q_3^2 + Q_4^2 \\
&\quad + 2k\eta\phi_1 Q_1 Q_2 + 2kQ_1 Q_4 + 2\eta\phi_1 Q_2 Q_4 \\
&\quad + \theta_\pi (k^2 Q_5^2 + (\eta\phi_1)^2 Q_6^2 + \sigma_u^2 Q_7^2 + Q_8^2 \\
&\quad + 2k\eta\phi_1 Q_5 Q_6 + 2kQ_5 Q_8 + 2\eta\phi_1 Q_6 Q_8) \\
&\quad + \theta_b (k^2 Q_9^2 + (\eta\phi_1)^2 Q_{10}^2 + \sigma_u^2 Q_{11}^2 + Q_{12}^2 \\
&\quad + 2k\eta\phi_1 Q_9 Q_{10} + 2kQ_9 Q_{12} + 2\eta\phi_1 Q_{10} Q_{12}) . \qquad (94)
\end{aligned}$$

C.2 Determination of the Expected Loss under a Free Float

Subject of this subsection is to determine the expected loss under a flexible exchange rate system. The second period loss was calculated in appendix B and is given by equation (82):

$$L_2 = (\pi_2^f)^2 \underbrace{\left(\theta_\pi + \theta_\pi^2 \left[\frac{(\kappa - q\beta b_1)^2 + (\theta_b w\kappa)^2}{(\gamma(\kappa - q\beta b_1) + wb_1(\kappa - q))^2}\right]\right)}_{=:R_0} = (\pi_2^f)^2 R_0 \ .$$

Furthermore, we use the two definitions $T := \theta_b F(\gamma E + F) + \theta_\pi (w\kappa)^2 + \theta_\pi \theta_b E^2$ and $\tilde{T} := \theta_b(\gamma E + F)^2 + \theta_\pi (w\kappa)^2 + \theta_\pi \theta_b E^2$. Of course, $\tilde{T}$ is strictly positive. T is in most of all cases also strictly positive as the signs of E and F are closely linked by the parameter values of κ and q and have thus in most cases the same sign as discussed before.

Then, the rational expectations equilibrium of inflation, π_2^{**f} can be written as

$$\begin{aligned}(\pi_2^{**f})^2 \quad = \quad & \Bigg(k \underbrace{\left[\frac{\theta_b E(\gamma E + F)}{T}\right]}_{=:R_1} + \eta\phi_1 \underbrace{\left[\frac{-qwb_1}{T}\right]}_{=:R_2} \\ & + u_2 \underbrace{\left[\frac{-\theta_b(\gamma E + F)wb_1 q}{\tilde{T}}\right]}_{=:R_3} + \underbrace{\left[\frac{wb_1\kappa}{T}\right]}_{=:R_4} \Bigg)^2 \ . \end{aligned} \tag{95}$$

The second period loss equals

$$\begin{aligned} L_2 &= R_0(kR_1 + \eta\phi_1 R_2 + u_2 R_3 + R_4)^2 \\ &= R_0(k^2 R_1^2 + (\eta\phi_1)^2 R_2^2 + u_2^2 R_3^2 + R_4^2 + 2k\eta\phi_1 R_1 R_2 + 2ku_2 R_1 R_3 \\ &\quad + 2kR_1 R_4 + 2\eta\phi_1 u_2 R_2 R_3 + 2\eta\phi_1 R_2 R_4 + 2u_2 R_3 R_4) \ . \end{aligned} \tag{96}$$

The expected value of L_2 is given by

$$\begin{aligned} E(L_2^{float}) &= R_0(k^2 R_1^2 + (\eta\phi_1)^2 R_2^2 + \sigma_u^2 R_3^2 + R_4^2 \\ &\quad + 2k\eta\phi_1 R_1 R_2 + 2kR_1 R_4 + 2\eta\phi_1 R_2 R_4) \ . \end{aligned} \tag{97}$$

C.3 Comparison of the Expected Losses

The difference of the expected losses under a currency board and a float is given by

$$\begin{aligned} D_2 &= E(L_2^{cboard}) - E(L_2^{float}) - c^{CB} \\ &= k^2 Q_1^2 + (\eta\phi)^2 Q_2^2 + \sigma_u^2 Q_3^2 + Q_4^2 + 2k\eta\phi_1 Q_1 Q_2 + 2kQ_1 Q_4 + 2\eta\phi_1 Q_2 Q_4 \\ &\quad + \theta_\pi(k^2 Q_5^2 + (\eta\phi_1)^2 Q_6^2 + \sigma_u^2 Q_7^2 + Q_8^2 + 2k\eta\phi_1 Q_5 Q_6 + 2kQ_5 Q_8 + 2\eta\phi_1 Q_6 Q_8) \\ &\quad + \theta_b(k^2 Q_9^2 + (\eta\phi_1)^2 Q_{10}^2 + \sigma_u^2 Q_{11}^2 + Q_{12}^2 + 2k\eta\phi_1 Q_9 Q_{10} + 2kQ_9 Q_{12} + 2\eta\phi_1 Q_{10} Q_{12}) \\ &\quad - R_0(k^2 R_1^2 + (\eta\phi_1)^2 R_2^2 + \sigma_u^2 R_3^2 + R_4^2 + 2k\eta\phi_1 R_1 R_2 + 2kR_1 R_4 + 2\eta\phi_1 R_2 R_4) - c^{CB} \ . \end{aligned} \tag{98}$$

As it is hardly possible to find an explicit solution, we do comparative statics to compare both systems in section 5.1 by using two numerical scenarios. The solution of D_2 is used for the MATLAB-simulations to obtain the numerical results and *is interpreted as a measure for the stability of a currency board system* in section 5.1.

D Comparison of a Currency Board and a Standard Peg

Before going through the technical details of the comparison of a currency board and a standard peg, we introduce briefly the assumptions made in this section:

- To compare the standard peg regime and the currency board arrangement, we use the probability of maintaining each system. We, henceforth, interpret the probability of maintaining an exchange rate system as the credibility of that system (a similar approach can be found in Drazen and Masson, 1994 or Feuerstein and Grimm, 2006).
- We have to calculate the maintaining probabilities by comparing the expected second period losses of a currency board / standard peg and the free float case from the view of period 0 after a shock materialized in period 0. In scenario I and II of section 5.2, we assume that there is no shock in period 0. Furthermore, we assume that the standard fixed exchange rate is defended in the first period (this means that the peg has an implicit commitment value in the first period after its introduction), but can be abandoned surprisingly in period 2. A currency board can only be abandoned in period 2, if this was announced in period one, before the private sector's wage bargaining (inflation expectations) takes place and before the second period shock occurs. Therefore, the maintaining interval of the currency board depends on ϕ_1 and the maintaining interval of the peg depends on ϕ_2. The preparations to establish a fair comparison of both systems despite the different timing of decision-making is done in the parts 2 and 3 of appendix D.
- When analyzing the standard peg system, multiplicities of π_2^e may occur if the private sector has rational expectations of inflation (see discussion in section 4). Therefore, in our calculations we treat π_2^e as an exogenous parameter. When comparing the credibility of a currency board arrangement with the credibility of a standard peg, we assume that inflation expectations under a standard peg are a mixture of expectations under a currency board (full credibility) and a free float system (zero credibility).

D.1 Second-period Loss Functions (for a given π_2^e)

In a standard peg regime, the policy maker decides whether to defend or to leave the exchange-rate peg after the realization of the second period shock. Therefore, a policy maker's decision is based on a comparison of the loss functions (56) and (82) for a given $\pi_2^{e,Peg}$ after the realization of the shock ϕ_2.

We begin with reformulating the loss function (56) by using the inflation equation (47), where π_2^e is taken as given. The first component of the loss function equals

$$\begin{aligned}
(y_2 - k)^2 &= \frac{1}{(\beta D)^2}\big((\beta A k + \beta\gamma A\pi_2^e + \phi_2(\theta_b B + wA) - \theta_b\beta B b_1)A \\
&\quad - \phi_2 w(\theta_b B^2 + A^2 + \theta_\pi\beta^2) - \gamma\pi_2^e(\theta_b\beta B^2 + \beta A^2 + \theta_\pi\beta^3) \\
&\quad - k(\theta_b\beta B^2 + \beta A^2 + \theta_\pi\beta^3)\big)^2 \\
&= \frac{1}{(\beta D)^2}\big(\beta(k(\theta_b B^2 - \theta_\pi\beta^2) + \phi_2(\theta_b B(\gamma + wb_1) - w\theta_\pi\beta) \\
&\quad + \pi_2^e(-\gamma\theta_b B^2 - \gamma\theta_\pi\beta^2) + (-\theta_b b_1 BA))\big)^2 \\
&= \frac{1}{D^2}\Bigg(k\underbrace{(\theta_b B^2 - \theta_\pi\beta^2)}_{=:P_1} + \phi_2\underbrace{(\theta_b B(\gamma + wb_1) - w\theta_\pi\beta)}_{=:P_2} \\
&\quad + \pi_2^e\underbrace{(-\gamma\theta_b B^2 - \gamma\theta_\pi\beta^2)}_{=:P_3} + \underbrace{(-\theta_b b_1 BA)}_{=:P_4}\Bigg)^2 . \qquad (99)
\end{aligned}$$

The second component of the loss function is rewritten as

$$\theta_\pi\pi_2^2 = \frac{\theta_b}{D^2}\Bigg(k\underbrace{(\beta A)}_{=:P_5} + \phi_2\underbrace{(\theta_b B + wA)}_{=:P_6} + \pi_2^e\underbrace{(\gamma\beta A)}_{=:P_7} + \underbrace{(-\theta_b\beta B b_1)}_{=:P_8}\Bigg)^2 . \qquad (100)$$

The third component $\theta_b b_2^2$ equals

$$\begin{aligned}
\theta_b b_2^2 &= \theta_b\left(\frac{B}{\beta}\pi_2 - \frac{\phi_2}{\beta} + b_1\right)^2 \\
&= \theta_b\left(k\left[\frac{AB}{D}\right] + \phi_2\left[\frac{wAB - A^2 - \theta_\pi\beta^2}{\beta D}\right] + \pi_2^e\left[\frac{\gamma AB}{D}\right] + \left[-\frac{\theta_b B^2 b_1}{D} + b_1\right]\right)^2 \\
&= \frac{\theta_b}{D^2}\Bigg(k\underbrace{[AB]}_{=:P_9} + \phi_2\underbrace{[-\gamma A - \theta_\pi\beta]}_{=:P_{10}} + \pi_2^e\underbrace{[\gamma AB]}_{=:P_{11}} + \underbrace{[b_1(A^2 + \theta_\pi\beta^2)]}_{=:P_{12}}\Bigg)^2 . \qquad (101)
\end{aligned}$$

Using the definitions P_1 to P_{12} in the loss L_2^{Peg} simplifies to

$$\begin{aligned}
L_2^{Peg} &= \frac{1}{D^2}\big[(kP_1 + \phi_2 P_2 + \pi_2^e P_3 + P_4)^2 + \theta_\pi(kP_5 + \phi_2 P_6 + \pi_2^e P_7 + P_8)^2 \\
&\quad + \theta_b(kP_9 + \phi_2 P_{10} + \pi_2^e P_{11} + P_{12})^2\big] . \qquad (102)
\end{aligned}$$

Now, we rewrite the loss function (82) of the free float case by inserting the inflation equation (78) while, again, treating π_2^e as given:

$$\begin{aligned}
L_2^f &= R_0\frac{\theta_b(\gamma E + F)}{\tilde{T}^2}\Bigg(k\underbrace{[E]}_{=:S_1} + \pi_2^e\underbrace{[\gamma E]}_{=:S_3} + \phi_2\underbrace{[-qwb_1]}_{=:S_2} + \underbrace{[\kappa wb_1]}_{=:S_4}\Bigg)^2 \\
&= R_0\frac{\theta_b(\gamma E + F)}{\tilde{T}^2}(kS_1 + \phi_2 S_2 + \pi_2^e S_3 + S_4)^2 , \qquad (103)
\end{aligned}$$

where R_0 and $\tilde{T}$ were defined in the second section of appendix C.

D.2 Credibility of a Standard Peg

To derive the range of the random variable ϕ_2 characterizing the second period shock for which the exchange-rate peg is defended, we have to solve the following inequality for ϕ_2

$$L_2^{Peg} \leq L_2^f + c \; . \tag{104}$$

Using the expressions for the loss functions, just derived in the first part of appendix D, we obtain the condition where the peg is defended as

$$\begin{aligned}
\frac{R_0\theta_b(\gamma E+F)}{\tilde{T}^2} & \left[k^2S_1^2 + \phi_2^2S_2^2 + (\pi_2^e)^2S_3^2 + S_4^2 + 2k\phi_2S_1S_2 + 2k\pi_2^eS_1S_3 + 2kS_1S_4\right. \\
& \left. +2\phi_2\pi_2^eS_2S_3 + 2\phi_2S_2S_4 + \pi_2^eS_3S_4\right] + c^{Peg} \\
-\frac{1}{D^2} & \left[k^2P_1^2 + \phi_2^2P_2^2 + (\pi_2^e)^2P_3^2 + P_4^2 + 2k\phi_2P_1P_2 + 2k\pi_2^eP_1P_3 + 2kP_1P_4\right. \\
& +2\phi_2\pi_2^eP_2P_3 + 2\phi_2P_2P_4 + \pi_2^eP_3P_4 \\
\theta_\pi & (k^2P_5^2 + \phi_2^2P_6^2 + (\pi_2^e)^2P_7^2 + P_8^2 + 2k\phi_2P_5P_6 + 2k\pi_2^eP_5P_7 + 2kP_5P_8 \\
& +2\phi_2\pi_2^eP_6P_7 + 2\phi_2P_6P_8 + \pi_2^eP_7P_8) \\
\theta_b & (k^2P_9^2 + \phi_2^2P_{10}^2 + (\pi_2^e)^2P_{11}^2 + P_{12}^2 + 2k\phi_2P_9P_{10} + 2k\pi_2^eP_9P_{11} + 2kP_9P_{12} \\
& \left. +2\phi_2\pi_2^eP_{10}P_{11} + 2\phi_2P_{10}P_{12} + \pi_2^eP_{11}P_{12})\right] \;\geq\; 0 \; .
\end{aligned} \tag{105}$$

We focus on deriving mathematical expressions for the boundaries of the "defending-interval" in case of a standard-peg regime, which can be determined if (105) holds with equality. The boundaries itself are functions which depend on expected inflation π_2^e and on the parameters $k, q, b_1, \eta\phi_1, \kappa, \beta, c^f, \theta_b, \theta_\pi$. We denote the set of parameters by $\mathcal{S}$ for reasons of clarity. Therefore, solving (105) for ϕ_2, we get the interval in which the standard peg is defended as

$$[\phi^{l,Peg}(\pi_2^e;\mathcal{S}), \phi^{u,Peg}(\pi_2^e;\mathcal{S})] \; . \tag{106}$$

Note that we set the probability of maintaining the standard peg equal to zero, if by solving the quadratic equation, which results from a comparison of the loss function for ϕ_2, the discriminant becomes negative. If we assume that the new shock u_2 is uniformly distributed with zero mean and standard deviation $\sigma_u > 0$, we obtain the boundaries of the interval of possible realizations of the second period shock ϕ_2 by[28]

$$\underline{\phi}_2 = \eta\phi_1 - \sigma_u\sqrt{3} \tag{107}$$

$$\overline{\phi}_2 = \eta\phi_1 + \sigma_u\sqrt{3} \; . \tag{108}$$

[28]The expected value of a uniformly distributed random variable u is given by $\mu_u = (\overline{\phi} + \underline{\phi})/2$ and the variance is given by $\sigma_u^2 = (\overline{\phi} - \underline{\phi})^2/12$. Using both equations, we can compute the support of u explicitly.

For the comparison of the standard peg and the currency board system, we define the credibility of both systems as the probability of maintaining the first-period exchange-rate systems also in the second period (see also FEUERSTEIN and GRIMM, 2006). The probability of defending the exchange rate under a standard peg in period 2 for a given realization of ϕ_1 equals

$$Prob(\text{maintain Peg}|\phi_1) = \max\left[\frac{\min(\overline{\phi}_2, \phi_2^{u,Peg}(\pi_2^e;\mathcal{S})) - \max(\underline{\phi}_2, \phi_2^{l,Peg}(\pi_2^e;\mathcal{S}))}{\overline{\phi}_2 - \underline{\phi}_2}, 0\right] . \tag{109}$$

To avoid an unfair comparison due to the different timing of decision-making in the standard peg and the currency board system caused by a particular choice of ϕ_1, we calculate the probability of maintaining the peg as an average over all possible realizations of ϕ_1, given by

$$Prob(\text{maintain Peg}) = \int_{\underline{\phi}_1}^{\overline{\phi}_1} Prob\,(\text{maintain Peg}|\phi_1)\, d\phi_1 . \tag{110}$$

Due to the assumption of a uniform distribution, we can approximate the probability by

$$Prob(\text{maintain Peg}) \approx \frac{1}{N}\sum_{n=0}^{N} Prob\left(\text{maintain Peg}\middle|\phi_1 = \frac{n}{N}\underline{\phi}_1 + \frac{N-n}{N}\overline{\phi}_1\right) . \tag{111}$$

In our numerical examples of section 5, we used $N = 50$ "drawings" from the distribution of ϕ_1.

D.3 Credibility of a Currency Board

To compare the standard peg system with that of a currency board, we have now to define how to measure the probability of maintaining the currency board. As decision-making under a currency board arrangement takes place in the first period, the maintaining-interval depends on the first period shock ϕ_1. Due to the assumption of a uniformly distributed shock, the support of ϕ_1 is given by

$$[\underline{\phi}_1, \overline{\phi}_1] = [-\sigma_u\sqrt{3}, \sigma_u\sqrt{3}].$$

In this context, remember the assumption already made in section 3 saying that $\phi_0 = 0$, which means that there is no inherited shock from period 0.

In the currency board case, multiple equilibria cannot occur due to the time structure assumed in the model. Therefore, we can insert the unique equilibrium value for π_2^e into the expected loss functions (see appendix C). To find the boundaries of the interval, in which the monetary authority announces the continuity of the currency board, we have to solve

$$E(L_2^{CB}) = E(L_2^f) + c^{CB}$$

for ϕ_1. We obtain two solutions, which determine the lower and upper boundaries of the maintaining-interval. They depend on the parameter set $k, q, b_1, \sigma_u, \kappa, \beta, c^f, \theta_b, \theta_\pi$, summarized by $\mathcal{R}$, henceforth. Analogically to the proceedings in the peg-case, we set the probability of maintaining the currency board equal to zero if the discriminant by solving the quadratic equation for ϕ_2 becomes negative. Then, the probability of announcing to maintain the peg can be calculated by

$$Prob(\text{maintain CB}) = \max\left[\frac{\min(\overline{\phi}_1, \phi_1^{u,CB}(\mathcal{R})) - \max(\underline{\phi}_1, \phi_1^{l,CB}(\mathcal{R}))}{\overline{\phi}_1 - \underline{\phi}_1}, 0\right] . \qquad (112)$$

References

[1] Alberola, Enrique and Luis Molina (2002): "Fiscal Discipline and Exchange Rate Regime - A Case for Curreny Boards", *Bank of Spain, Working Paper*, No. 0006.

[2] Aloy, Marcel; Blanca Moreno-Dodson and Gilles Nancy (2003): "Does Fiscal Policy Matter in a Currency Board Regime? The Case of Argentina", CEDERS, Preliminary Draft.

[3] Barro, Robert J. and David B. Gordon (1983): "A Positive Theory of Monetary Policy in a Natural Rate Model", *Journal of Political Economy*, vol. 91, 589-610.

[4] Berger, Helge; Henrik Jensen and Guttorm Schjelderup (2001): "To Peg or not to Peg? A Simple Model of Exchange Rate Regime Choice in Small Economies", *Economic Letters*, vol. 73, 161-167.

[5] Calvo, Guillermo (2000): "The Case for Hard Pegs in the Brave New World of Global Finance", Inter-American Development Bank, http://www.iadb.org/res/publications/pubfiles/pubP-101.ppt.

[6] Carlson, John A. and Neven T. Valev (2001): " Credibility of a New Monetary Regime: The Currency Board in Bulgaria", *Journal of Monetary Economics*, vol. 47, 581-594.

[7] Catão, Luis and Marco E. Terrones (2003): "Fiscal deficits and Inflation", *IMF Working Paper*, WP/03/65.

[8] Chang, Roberto and Andrés Velasco (2000): "Financial Fragility and the Exchange Rate Regime", *Journal of Economic Theory*, vol. 92, 1-34.

[9] De la Torre, Augusto; Eduardo Levy-Yeyati and Sergio L. Schmukler (2005): "Living and Dying with Hard Pegs: The Rise and Fall of Argentina's Currency Board", *Economia*, vol. 5, 43-99.

[10] Enoch, Charles and Anne-Marie Gulde (1998): "Are Currency Boards a Cure for all Monetary Problems", *Finance and Development*, December, 40-43.

[11] Fatas, Antonio and Andrew K. Rose (2001): "Do Monetary Handcuffs Restrain Leviathan? Fiscal Policy in Extreme Exchange Rate Regimes", *IMF Staff Papers*, vol. 47.

[12] Feuerstein, Switgard and Oliver Grimm (2006): "On the Credibility of Currency Boards", *Review of International Economics*, vol. 14(5), 818-835.

[13] Grigonyte, Dalia (2003): 'Impact of Currency Boards on Fiscal Policy and Eastern European Countries", *Economics of Planning*, vol. 36, 111-133.

[14] Ghosh, Atish R.; Anne-Marie Gulde and Holger Wolf (2000): "Currency Boards: More than a Quick Fix?", *Economic Policy*, vol. 31, 269-335.

[15] HAMANN, Javier A. (2001): "Exchange-Rate-Based Stablization: A Critical Look at the Stylized Facts", *IMF Staff Papers*, vol. 48, no. 1.

[16] HO, Corinne (2002): "A Survey of the Institutional and Operational Aspects of Modern-Day Currency Boards", *BIS Working Paper No. 110.*

[17] IRWIN, Gregor (2004): "Currency Boards and Currency Crises", *Oxford Economic Papers*, vol. 56, 64-87.

[18] OBSTFELD, Maurice (1996): "Models of Currency Crises with Self-fulfilling Features", *European Economic Review* vol. 40, 1037-1047.

[19] OLIVA, Maria-Angels, Luis A. RIVERA-BATIZ and Amadou N. R. SY (2001):, "Discipline, Signaling, and Currency Boards", *Review of International Economics*, vol. 9, 608-625.

[20] SACHS, Jeffrey; Aarón TORNELL and Andrés VELASCO (1996):"The Mexican Peso Crisis: Sudden Death or Death Foretold", *Journal of International Economics*, vol. 41, 265-283.

[21] TORNELL, Aarón and Andrés VELASCO (1998): "Fiscal Discipline and the Choice of a Nominal Anchor in Stabilization", *Journal of International Economics*, vol. 46, 1-30.

[22] TORNELL, Aarón and Andrés VELASCO (1995a): "Money-Based versus Exchange Rate-Based Stabilization with Endogenous Fiscal Policy", *NBER Working Paper*, no. W5300.

[23] TORNELL, Aarón and Andrés VELASCO (1995b): "Fixed versus Flexible Exchange Rates: Which Provides More Fiscal Discipline?", *NBER Working Paper*, no. W5108.

[24] TORNELL, Aarón and Andrés VELASCO (1998): "Fiscal Discipline and the Choice of Exchange Rate Regime", *European Economic Review*, vol. 39, 759-770.

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