Welfare analysis of currency regimes with defautable debt

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Abstract

We modify the Cole and Kehoe ([5], [6] and [7]) general equilibrium model with defaultable debt denominated in a foreign currency. We consider two additional cases: the first one treats the case of a country that has debt denominated in both a local and a foreign currency; the second one considers the case of a country that joins a monetary union and can therefore influence policies decisions. In the original case of Cole and Kehoe, which we call dollarization, the country can either make a sharp fiscal adjustment or default when subject to a speculative attack on its debt. In the first additional case, besides both options of dollarization, the country can also inflate the local debt. In the second additional case, the country must convince the monetary union to inflate. We then carry out a welfare analysis of the three cases and indicate the optimal monetary arrangement, depending on the characteristics of the country. Although the paper was originally developed for emerging market economies, it is also useful to understand other cases as the current crisis in the Eurozone.

Keywords: dollarization, optimum currency area, speculative attacks, debt crisis

JEL Classification: F34, F36, F47, H63

1 Introduction

Macroeconomic instability led to the debate of dollarization in the 1990's and Argentina went further in this direction by adopting a currency-board regime from April 1991 to January 2002 and issuing high levels of debt denominated in foreign currency. This type of debt aims at protecting investors from a depreciation of the local currency. An adverse effect, however, is that it also makes them fear that a steep depreciation would actually cause a default.

Other emerging market economies of Latin America and Southeast Asia were also heavily indebted in the 1990's. High international liquidity helped sustain stabilization programs and strengthen the value of national currencies. Reversal of market expectations and contagion effects changed this environment, causing financial crises in some of these economies. Argentina and Russia actually defaulted, while Mexico, Korea, Thailand, the Philippines, Malaysia, Indonesia and Brazil experienced severe devaluation of their currencies.

Besides the emerging markets of Latin America and Southeast Asia, some countries of the European Monetary Union have suffered speculative attacks on their public debt during 2010. The so-called GIIPS (Greece, Italy, Ireland, Portugal and Spain) have been facing difficulties to persuade the monetary union to inflate, meanwhile a default on their public debt would ruin the credibility of the common currency.

With this background in mind, we make an extension to the Cole and Kehoe ([5], [6] and [7]) model on self-fulfilling debt crisis to discuss some financial aspects of three currency regimes: dollarization, local currency and common currency.

In this paper we do not model explicitly inflation, exchange rate and monetary policy in the traditional way found in international monetary economics. We simply resume in the analysis, the consequences of the devaluation of a currency and the consequences of inflation in terms of the purchasing power of a currency. We refer to this as partial default, in the sense that the bond issued by the government will not have the same value, in real terms, as before.

The amount of the real return that is reduced is chosen by the government that issues debt denominated in local currency, as if it has autonomy to decide about its inflation rate. We call this regime the "local-currency regime". When the fraction to be reduced of the real return is chosen by member countries of a monetary union that issue debt denominated in a common currency, we call this regime "common currency". In a country that only issues debt denominated in the currency of another country, the government is not able to reduce the real return on this debt. We call this regime, dollarization. The original Cole-Kehoe model can be viewed as an approximation to dollarization.

Under dollarization, as was the case of Argentina during its Convertibility Plan in the 1990's, the national government loses control over its monetary policy through a hard peg to a foreign currency. Some economists argue that this regime provides for large credibility gains, because monetary policy is strongly committed to low inflation (Hanke and Schuler [10]). However, monetary policy can become powerless to react to external shocks in dollarized economies unless there is strong symmetry between the effect of such shocks and that of the anchor country.

To represent a local-currency regime, we modify the original Cole-Kehoe model by allowing the government to issue, not only debt denominated in foreign currency, but also debt denominated in local currency. A national government issuing local-currency debt can decide to make a partial default on local-currency debt (*i.e.* pay only a fraction of the real return on these bonds), use the revenues so raised to honor its commitments with international bankers and avoid an external crisis. By adding debt in local currency, we model the government power to do monetary policy, which is absent under dollarization.

Unfortunately, the monetary flexibility attained with the local-currency regime, in the sense of the government being able to choose its inflation rate and consequently the real return on the public debt denominated in local currency, can make such a regime less credible. Credibility is lost whenever domestic political factors influence government decision of whether or not to make a partial default. Our model characterizes this situation by an exogenous shock called political inflation, which intends to capture the lack of a commitment technology of the national government.

Dollarization increases the credibility of monetary policy by refraining these suboptimal inflation levels, which arise when the government decides to make a partial default meanwhile there are no speculative attacks on its debt denominated in foreign currency. Even though we do not actually estimate the degree of dependence of a central bank, this political shock tries to capture the degree of central bank dependence on the national government.

The debate about local-currency regime versus dollarization was brought about in two papers by Araujo and Leon ([2] and [3]) published before the Argentine crisis[1]. As argued there, the dollarization regime does not necessarily lead to the highest welfare level relative to a regime in which it is possible to issue debt denominated in local currency. Similarly, Sims [18] points out the advantages of surprise inflation as a solution to smooth situations of fiscal stress which is absent under dollarization. Sargent [16], commenting on Sims' paper, points out to the lack of models that discuss dollarization. Here, we extend further such welfare analysis by adding debt denominated in common currency to the original Cole-Kehoe model. By doing so, we also resort to a general equilibrium model, like Neumeyer [14], to evaluate financial aspects of a common-currency regime.

[1]A first version of this paper was presented at the Fifth LACEA/IADB/UTDT Workshop in International Economics and Finance, at the Universidad Torcuato Di Tella, in Buenos Aires, August 19, 2002, receiving interesting comments.

Under a common-currency regime, it is possible to make a partial default on the debt denominated in common currency. The decrease in its real return, however, is decided according to a process established among the members of the monetary union. The way that this decision is taken affects each member's ability to make partial default on common-currency debt and therefore smooth the effects of speculative attacks. We consider two decision rules: in the first one, there is no partial default on the common-currency debt unless every country in the union votes in favor of it; and in the second one, one country is chosen randomly to decide about whether or not to partial default on the common-currency debt. In both cases, the credibility of the common currency might be enhanced relatively to the local currency. Since credibility falls when the decision to partial default is political, having more than one country to share the decision of whether or not to partial default on common-currency debt makes it more difficult for a political decision to come about. Table 1 shows the effects of monetary flexibility versus currency credibility, according to the three alternative currency regimes we consider in this paper.

One of the advantages of the Cole-Kehoe methodology is to do welfare analysis. We carry out simulations for Brazil during the 1998-2001 period. We compare the expected welfare levels of a local-currency regime with that of dollarization in order to prepare the way to understand why Brazil and Argentina were under different currency regimes between 1998 and 2001. We go back in time since both countries had pegged their currencies to the dollar during the early 1990's, but followed distinct regimes after the Russian default in August 1998. Brazil adopted a floating exchange rate regime in January 1999, which resembles our local-currency model, while Argentina maintained the currency-board regime, which is similar to what we describe as dollarization. These facts led to a moderate inflation in Brazil as of 1999 and caused a default on the external debt in Argentina in late 2001. If Argentina had debt denominated in local currency, the crisis might have been avoided.

We also compare the welfare levels across the three currency regimes conditional to the country being in the crisis zone. We make this assumption, in the simulations, because Brazil and Argentina have historically been under this situation as shown in Reinhart, Rogoff and Savastano ([15]). It might be an optimal strategy to be indebted in a foreign currency with possible default. If the bad state does not occur, then the country continues rolling its foreign debt. We do not consider debt levels below the crisis zone because we aim at appraising this aspect of the trade-offs of alternative regimes.

The same methodology could also be applied to appraise the current lack of monetary flexibility in Greece. Even though the Greek debt level is mostly denominated in a common currency (the Euro, not the Dollar) and it is mostly in the hands of the members of the European Monetary Union, as the national government does not have any power to inflate the Euro and most of the debt holders are not Greeks, we interpret Greece as a dollarized economy.

Our main result is that for a country with a highly-credible currency, *i.e.* a currency whose debt has a very low probability of suffering a partial default for political reasons, the local-currency regime is the best choice in terms of welfare. Conversely, for a low-credible currency, local currency is not the best choice. In this case, welfare becomes higher under either dollarization or common-currency regime, depending on the correlation of external shocks across the countries that share the decision to partial default on common-currency debt. When the correlation is low, it pays off for the country to dollarize in order to avoid both the productivity loss and the rise in interest rates that occurs when the decision to partial default prevails and is against its vote. When the correlation is high, it is better in terms of welfare to share a common decision to partial default, meaning that the partner countries tend to agree more on this decision. In sum, welfare computations indicate that the best is to have: (i) a share of the total debt denominated in common currency when external shocks are highly correlated across union members; (ii) a share of the total debt denominated in local currency when such correlation is low; and (iii) debt exclusively denominated in foreign currency when, not only the correlation is low, but also political inflation is very likely.

This paper is related to several works on quantitative models of sovereign defaultable debt. Rocha, Giménez and Lores [9] also modify the Cole and Kehoe model to include an important dimension of the Argentine crisis: the welfare implications coming from local-currency devaluation. According to their model, devaluation triggers productivity losses, but this procedure might be desirable as it increases the final welfare through the local consumers' utility augment. In our paper, the same is true. However, the benefits from devaluation are captured in each paper in a different way. In our paper, a currency devaluation in the sense of a partial default on local-currency or common-currency debt might avoid extreme cuts in the public expenditure, by reducing the real value of public debt. In Da-Rocha *et al.* [9], local-currency devaluation increases the value of foreign securities held by local consumers.

Another stream of academic work also related to sovereign defaultable debt is more concerned with the real business cycle behavior of emerging market economies. Arellano [4] aims at capturing the relationship between interest rates and business cycles and, in particular, replicates the business cycles of Argentina in the 2001 default episode. Aguiar and Gopinath [1] bring the rate of default close to that observed empirically by characterizing the income process as a volatile stochastic trend instead of an i.i.d. shock around a stable trend. Following the previous two works, Yue [19] introduces endogenous debt recovery rates which affect a country's ex-ante decision to default and replicates the bond spreads of Argentina for the period 1994 to 2001. Cuadra and Sapriza [8] explore the channels through which a country's political process might affect its sovereign debt default incentives and interest rate spreads. Our paper, however, is more concerned with the relative cost of default. International default still lacks good institutional arrangements. It has been tried to be established for countries a tool like the Chapter Eleven of the United States Bankruptcy Code, but it did not proceed because there are no enforcement agents. In practice, the penalty for an international default is the suppression of trade credit lines, which actually hurts the productivity of the country very much. The introduction of debt denominated in local currency or in common currency can give rise to the possibility of a better bankruptcy technology in practice through inflation than just the default, which can be quite costly.

2 The Model with Debt Denominated in Two Currencies

Cole and Kehoe developed a dynamic, stochastic general equilibrium model in which they consider the possibility of occurring a self-fulfilling crisis of the public debt denominated in foreign currency and held by international bankers. A self-fulfilling debt crisis takes place when foreign creditors have very low confidence that the government will honor its debt obligations. Consequently, they do not renew their loans and the government defaults.

Among their results, Cole and Kehoe show that when the public debt falls in an interval they call the *crisis zone*, the government finds it optimal to default if it cannot sell new debt. They characterize the crisis zone for different average maturities of the public debt and, for a given maturity, the crisis zone is defined as the debt interval for which there is a positive probability of a self-fulfilling debt crisis occurrence.

In this section, we modify the Cole-Kehoe model in order to assess the welfare of an economy with public debt denominated in two currencies: local and foreign currency. The local-currency debt is added to the model with the subterfuge that the government has some control over the monetary policy. This ability, which is absent under dollarization, consists of imposing a reduction on the real return of the debt denominated in local currency. The revenues so collected through this inflation tax can be employed to avoid a default on the external debt or to create inflation tax for political purposes in the absence of an external crisis. An alternative source to increase government revenue could be the raising of the income tax rate. Since we are considering the decisions of economic agents after the culmination of a shock, their decisions must be taken in a shorter time period compared to a change in the income tax rate, which usually has to wait for the next fiscal year.

The model with debt denominated in local currency closely resembles that of the original Cole-Kehoe model. There is one good produced with capital, k, inelastic labor supply and price normalized at one unit of the foreign currency. The economy consists of three participants — national consumers, international bankers and the government. Public debt denominated in foreign currency, B^*, is supposed to be acquired only by international bankers, there is a probability π of no rollover if its level is in the crisis zone and any suspension in payment is always total. We assume that public debt denominated in local currency, B, is taken up exclusively by national investors, there is always a credit rollover and repayment is suspended only partially.[2]

Inflation decisions imply a loss of credibility and a fall in welfare. Less credibility raises the cost of borrowing of the bond denominated in local currency and also, a reduction in the productivity level of the economy. The welfare cost of default on debt denominated in foreign currency is the same as in the Cole and Kehoe model: exclusion from the international lending market leading to a loss of productivity.

To avoid technical difficulties, governments can only choose to default either on debt denominated in foreign currency or on debt denominated in local currency, but not to default on both debts at the same time. Our model describes a dichotomous decision, because it is already very complex by itself. An improvement of our framework would include simultaneous default and inflation. Moreover,

[2]Since our hypothesis is that debt denominated in foreign currency is only acquired by international bankers, then this debt can also be referred to as external debt. Analogously, debt denominated in local currency can be referred to as domestic debt, since we assume that it is completely purchased by local investors.

this supposition is in accordance with our numerical exercise. In 1998, the year that Brazil suffered a speculative attack, 68 percent of its total net public sector debt was issued internally and denominated in local currency. The adoption of a flexible exchange rate regime in January 1999 allowed a decrease of interest rates and gave some room for inflation. Argentina faced a quiet different situation. During 1998-2002, 93 to 99 percent of total public sector debt was denominated in foreign currency. Therefore, the Argentine option to default partially on local-currency debt would be meaningless.

2.1 Description of market participants

2.1.1 Consumers

At time t, the representative consumer maximizes the expected utility

$$\max_{c_t, k_{t+1}, b_{t+1}} E \sum_{t=0}^{\infty} \beta^t \left[c_t + v\left(g_t\right) \right] \tag{1}$$

subject to the budget constraint, given by

$$c_t + k_{t+1} - k_t + q_t b_{t+1} \leq (1-\theta)\left[a_t f\left(k_t\right) - \delta k_t\right] + b_t - (1-\vartheta_t) b_t$$

with $k_0 > 0$ and $b_0 > 0$. At time t, the consumer chooses how many goods to save for the next period, k_{t+1}, to consume at present, c_t, and the amount of new local-currency debt to buy, b_{t+1}, which consists of zero-coupon bonds maturing in one period. The utility has two parts: a linear function of private consumption, c_t, and a function v of government spending, g_t. The function $v(.)$ is continuous, differentiable, strictly concave and increasing.

The left-hand side of the budget constraint includes the expenditure on consumption, investment and new local-currency debt, $q_t b_{t+1}$. We also assume that the consumer initially holds an amount k_0 of local goods and b_0 of local-currency debt .

The right-hand side of the budget constraint corresponds to the sum of the consumer's income from production after taxes and depreciation (θ is the tax rate, $\theta \in (0,1)$, and δ is the depreciation rate), and the revenue received from the purchase of local-currency debt in the previous period. ϑ_t is the government's decision variable on whether or not to inflate, which reduces the real return on local-currency debt.

When purchasing a local-currency bond, an investor pays q_t in t to receive 1 or ϕ, $\phi \in (0,1)$, units of the local good in $t+1$, depending on whether or not the government decides to inflate. If it chooses not to inflate, then $\vartheta = 1$; otherwise, $\vartheta = \phi$. The expression $b_t (1 - \vartheta_t)$ is the revenue that the government raises by inflating.

The government chooses a constant inflation rate given by expression $\left(\frac{1-\vartheta}{\vartheta}\right)$. The choice set for the inflation rate is the positive part of the real line and zero. When running its monetary policy, the government aims at an inflation rate and ϑ tries to capture its decision.

The production function, $f(.)$, is continuous, concave, differentiable and strictly increasing[3]. If the government decides to inflate or to default, the productivity, a_t, suffers a permanent fall [4]:

$$\begin{aligned}(a_t|\text{ inflation}) &= \alpha^{\phi} \\ (a_t|\text{ default}) &= \alpha \\ a_t &= 1,\text{ otherwise,} \\ where &: 0 < \alpha < \alpha^{\phi} < 1\end{aligned}$$

2.1.2 International bankers

The problem of the representative international banker is analogous to the consumer problem, except that the instantaneous utility excludes the term related to government spending, and consists of

$$\max_{x_t, b^*_{t+1}} E \sum_{t=0}^{\infty} \beta^t x_t \tag{2}$$

$$s.t.\ \ x_t + q^*_t b^*_{t+1} \leq \overline{x} + z_t b^*_t$$

given an initial amount of public debt

$$b^*_0 > 0$$

At time t the bankers choose how many goods to consume, x_t, and the amount of government bonds to buy, b_{t+1}, given an endowment $\overline{x}$ of consumer goods. The

[3] $f(0) = 0;\ f\prime(0) = \infty;\ f\prime(\infty) = 0$

[4] The inflation impact on productivity is lower than the default impact. For this conclusion, we take the welfare cost of inflation calculated for Brazil by Simonsen and Cysne ([17]) and used the estimated cost of default for Mexico computed by Cole and Kehoe ([5]).

left-hand side of the budget constraint shows the expenditure on new government debt, where q_t^* is the price of one-period bonds that pay one unit of the good at maturity if the government does not default. The right-hand side includes the revenue received from the bonds purchased in the previous period, $z_t b_t^*$. The decision variable z indicates government default $(z = 0)$ or not $(z = 1)$. If it defaults, then the bankers receive nothing.

2.1.3 The Government

The government is assumed benevolent, in the sense that it maximizes the welfare of national consumers, and with no commitment to honor its obligations. Its decision variables are: new debt denominated in local currency, B_{t+1}; new debt denominated in foreign currency, B_{t+1}^*; and government consumption, g_t. It also chooses either to default or to inflate (z_t, ϑ_t) according to the following budget constraint:

$$\begin{aligned} g_t + z_t B_t^* + \vartheta_t B_t &\leq \theta \left[a_t f(K_t) - \delta K_t \right] + q_t^* B_{t+1}^* + q_t B_{t+1} \quad (3) \\ z_t &\in \{0,1\}\, ; \vartheta_t \in \{\phi, 1\} \text{ and } \phi \in (0,1) \\ g_t &\geq 0 \\ (z_t + \vartheta_t) &\geq 1 \end{aligned}$$

The left-hand side of expression (3) refers to the government current consumption and the payment of its debt. The right-hand side includes revenue from income taxes and from the selling of new debt. The government is also assumed to have a strategic behavior since it foresees the optimal decision of the participants, including its own, c_t, k_{t+1}, q_t^*, q_t, z_t, ϑ_t and g_t, given the initial aggregate state of the economy, s_t, and its choice of B_{t+1} and B_{t+1}^*.

According to our defintion, a dollarized economy is a special case of the economy with local currency described above. There is no possibility to inflate, because all public debt is denominated in foreign currency. Therefore, $\vartheta_t = 1$ and $B_t = 0$, for all t.

In the next section, to simplify the calculations, we consider the economy as if it lasted for only two periods.

2.2 The economy in two periods

In the initial period, $t = 0$, the economy is in equilibrium with capital stock, K_0, public debt denominated in foreign currency, B_0^*, public debt denominated in local currency, B_0, and productivity level, a_{-1}, equal to one. The debt denominated in foreign currency is in the crisis zone and there has been no shock, so $z_{-1} = 1$ and $\vartheta_{-1} = 1$. We make the assumption that new public debt, B_1^* and B_1, are sold in $t = 0$ at the same levels as in $t = -1$. Only the price of foreign-currency debt, q_0^*, the price of local-currency debt, q_0, and the investment level, K_1, depend on the different uncertainties a country faces in the following period according to the monetary regimes.

Under local-currency regime, at $t = 1$, the economy is subject to two shocks: political inflation and speculative attack on its foreign-currency debt. After uncertainty is solved, the government chooses, under a stationary debt policy, new debt levels, B_2^* and B_2, and also decides whether or not to default or whether or not to inflate. As from $t = 1$ on, these debt levels are kept constant and also z_1 and ϑ_1 remain unchanged, then the economy with infinite periods can be described by only two periods in which the second one is a perpetuity with public debt represented by a flow of interest rate over this amount.

2.3 Uncertainty

Uncertainty about a speculative attack is included into the model by the exogenous variable, ζ. Realization of ζ indicates the confidence that international bankers have that the government will not default on foreign-currency debt. It is assumed independent and identically distributed with uniform [0,1] distribution[5].

According to the Cole and Kehoe model, variable ζ can be viewed as a fundamental that drives confidence and defines the equilibrium in the crisis zone: either international bankers refuse to purchase new foreign-currency debt and default is the optimal decision; or they purchase new debt and there is no default. The speculative attack may be triggered in response to a change in economic

[5] Arellano [4] describes an income shock and assumes it as i.i.d. In our paper, the income is also affected by shocks which affect productivity, a_t.

fundamentals, not explicitly described in the model, such as: a change in prices of a commodity that intensively takes part in exports; a change in the government preferences after national elections; a reduction in international liquidity, among others.

Since it is not realistic to assume that each investor knows in equilibrium exactly what other investors do, we consider two critical values for the confidence variable instead of one as in the Cole and Kehoe model: a low value, π^d, and a high value, π^{up}. If $\zeta < \pi^d$, the international bankers' confidence is low and they do not renew their loans, then the price of new foreign-currency debt is zero and default is the government's optimal decision. If $\zeta \geq \pi^{up}$, then all investors are willing to purchase new debt at a positive price and default is not optimal. Our innovation is the case that we call a moderate attack, which is described as the interval for ζ given by $\pi^d \leq \zeta < \pi^{up}$. Under this condition, a partial rollover takes place. Fewer bankers are willing to purchase new debt at a positive price and so the government can renew only a fraction, φ, of its foreign-currency debt. We set φ less than one, but sufficiently large so that the government prefers to inflate rather than default during a moderate attack.

A second type of uncertainty comprises a shock that occurs when public debt denominated in local currency is inflated away for political reasons in the absence of speculative attacks. Political pressures are absent in the Cole-Kehoe model. In spite of the fact that international bankers roll over their loans, the government decreases the real return on local-currency debt for the purpose of generating extra revenues. The probability that this shock occurs, given that there is no speculative attack, is denoted by ψ and its unconditional probability is equal to $\psi(1-\pi^{up})$. Defining $\pi^{up\psi}$ as $\pi^{up}+\psi(1-\pi^{up})$, the political shock occurs if $\pi^{up} \leq \zeta < \pi^{up\psi}$. There are no shocks with probability $\left(1-\pi^{up\psi}\right)$.

In the beginning of period $t=1$, uncertainty is solved with the drawing of ζ. There are four possible states in $t=1$, as described in Table 2. The state s occurs if $\zeta \in \Pi_s$, where $\Pi_d \equiv [0,\pi^d)$; $\Pi_i \equiv [\pi^d,\pi^{up})$; $\Pi_p \equiv [\pi^{up},\pi^{up\psi})$; and $\Pi_c \equiv [\pi^{up\psi},1]$. Defining $\pi^i \equiv \pi^{up}-\pi^d$, $\pi^p \equiv \pi^{up\psi}-\pi^{up}$, and $\pi^c \equiv 1-\pi^{up\psi}$, the probability of occurrence of state s is given by π^s. All the participants know the critical values and the distribution of ζ and the outcome of ζ also drives consumer's actions.

The timing of actions within period $t=1$ is:

- ζ is realized and the aggregate state is $s_1=(K_1,B_1,B_1^*,a_0,\zeta_1)$;
- the government, given the price function $q^*=q^*(s_1,B_2^*)$, chooses B_2^* and given the price function $q=q(s_1,B_2^*,B_2)$ chooses B_2;
- the international bankers decide whether or not to purchase B_2^*;
- the government chooses whether or not to default, z_1, whether or not to inflate, ϑ_1, and how much to consume, g_1;

- finally, consumers, given $a(s_1, z_1, \vartheta_1)$, decide about c_1, k_2 and b_2.

3 The Model with Common Currency

We modify the model with local currency to assess the welfare of a country that shares its monetary policy decision with another country or a group of countries in order to enhance credibility. We call this arrangement a monetary union which is mainly characterized as having debt denominated in two currencies (the common currency and the foreign currency), n member countries and a union's central bank. Each member country of the union is denoted as country j, where $j \in \{1, 2, ..., n\}$. When these countries decide to create a monetary union, their debt denominated in local currency is replaced by debt denominated in common currency. Since there is a common-currency debt, it is possible to collect inflation tax, but this decision depends on each one of the countries having influence over the decision-making process for inflation. The decision variable ϑ for the union is denoted by ϑ^u, and the decision variable ϑ for each member country, ϑ^j, $j \in \{1, 2, ..., n\}$.

The description of the economic agents is analogous to the model with local currency. We define once again the budget constraint for the international bankers, so as to consider foreign-currency debt levels they acquire from each j^{th} member country of the union, b_{t+1}^{j*}, at price, q_t^{j*}:

$$x_t + \sum_{j=1}^{n} q_t^{j*} b_{t+1}^{j*} \leq \overline{x} + \sum_{j=1}^{n} z_t^j b_t^{j*}; \forall t$$

To estimate the welfare of country j in a monetary union, we need to define its influence on the decision process for inflation. Two possibilities are considered.

First, we assume that every member of the union has the right of veto over the union's decision to inflate. Therefore, inflation takes place if all members simultaneously vote for it. Considering the right of veto, when a country joins a monetary union, its decision to default on debt denominated in foreign currency is not changed in comparison to the local-currency regime. However, its decision to inflate under a situation of moderate attack may not take place if the union's decision is against it. In this case, the country has to choose between default or respect debt contracts.

An alternative way of choosing to inflate is one in which each country j has some political influence over the union's central bank. If the member countries do not agree on inflating, we assume that each one of them will succeed in implementing its decision with probability pw^j. The variable pw^j is the political weight of the country j. The greater pw^j is, the stronger is its influence on the union's central bank.

Under this decision process, a country's decision to default is changed in comparison to the local-currency regime. If country j chooses to default while the union decides for inflation, then inflation takes place. As we ruled out the possibility of default and inflation at the same time, then country j cannot default by itself.

Only if public expenditure becomes negative when default is avoided, then default and inflation can occur at the same time. For such situation, the productivity measure a_t is $\alpha \cdot \alpha^{\phi}$.

These two types of decision processes are chosen for didactic purposes. For the second type, additional uncertainty is taken into account.

3.1 Uncertainty

Uncertainty about a speculative attack is included in the model with debt denominated in common currency in an analogous way as in the model with debt denominated in local currency. The exogenous variables, ζ^j, $j \in \{1, 2, ..., n\}$ indicate the confidence that international bankers have that the government from country j will not default on its foreign-currency debt. We assume that ζ^j has the same distribution and critical values for each country j and that all countries know the correlation between events related to the realization of the sunspots $\left\{\zeta_1^1, ..., \zeta_1^n\right\}$.

We consider the following structure of correlations between events related to speculative attacks: the probability that an intense attack in country j occurs, $Prob(\zeta^j \leq \pi^d)$, does not depend on events that take place in other countries. If an intense attack does not occur in any country at the union while a moderate attack does in all of them, then the events with symmetry of attacks between members are positively correlated by ρ. If $\rho = 0$, then the attacks occur independently. If

$\rho = -1$, then they are asymmetrical.

Thus, in a monetary union with right of veto, each member country is subject to five possible states, instead of four, as we saw in the model with debt denominated in local currency. The decision process to inflate adds further uncertainty. The additional state u is defined as one in which the country suffers a moderate attack but cannot practice the desired inflation since at least one country votes against that. Accordingly, this country has to choose between default on its debt denominated in foreign currency or respect contracts. If country j votes for inflation in the absence of an attack (the political inflation shock), but another country vetoes its choice, then j visits state c (respect contracts) and moves out from state p (political inflation). Country j can visit state p, whenever its decision for inflation is aligned with the other members' vote for inflation. The probability of state d (intense attack) is not altered by the voting system when veto is allowed.

Table 3 shows five events (from a total of 16), as well as their probability of occurrence, for a member of a monetary union formed by two identical countries A and B with right of veto. The calculation of these probabilities is detailed in Appendix A. Appendix A also contains the major events for a country when the union is made up of three identical countries and there are 64 possible events.

In a monetary union in which each country believes that it exerts some political influence over the union's central bank, then each member is subject to six possible states instead of five. The sixth state, denoted by w, occurs when the country suffered an intense attack, but can not practice the desired default since the union's central bank had decided for inflation. Under this situation, if the government revenue (including the inflation tax) is not enough to pay for the foreign-currency debt, we assume that this country practices default and inflation[6]. Table 4 sums up six major events (from a total 16), as well as their probability of occurrence, for a member of a monetary union of this type and formed by two identical countries A and B.

In both types of monetary union, the possibility of inflation to avoid an external default is reduced, but not ruled out as in dollarization. Inflation to avoid default on foreign-currency debt is prevented by the union, when the state changes from i (moderate attack) to u (moderate attack with veto). Conversely, political inflation is also prevented when the state changes from p (political inflation) to c (respect contracts).

3.2 Timing of actions within a period

The timing of actions within period $t = 1$ is:

- ζ^j is realized and the aggregate state of the economy j is S_1^j =

[6] In our model with debt denominated in local currency, the inflation tax avoids a default on debt denominated in foreign currency, when the country suffers a moderate attack. To make calculations simpler, we do not include a state of nature in which simultaneous default and inflation could occur. In our model with debt denominated in common-currency, we make an exception in order to avoid a negative government consumption.

$(K_1^j, B_1^{j*}, B_1^j, a_o^j = 1, \zeta^j)$ and the aggregate state of the union of n countries is S_1, $S_1 = \{S_1^1, ...S_1^n\}$;

- government j, taking S_1 as given, chooses $\vartheta^j \in \{\phi, 1\}$;
- government j, taking S_1, ϑ^u and the price q^{j*}as given, chooses the new foreign-currency debt B_2^{j*};
- international bankers, taking S_1, ϑ^u and q^{j*} as given, choose whether or not to purchase new foreign-currency bonds, b_2^{j*}, issued from each country j;
- government j, taking S_1, ϑ^u and the price q_1^j as given, chooses the new common-currency debt B_2^j;
- investors from country j, considering S_1, q_1^j, q_1^{j*} and ϑ^u as given, choose whether or not to purchase common-currency bonds issued by their own country b_2^j;
- government j, knowing ϑ^u, B_2^j and B_2^{j*}, chooses whether or not to default, z_1^j, and how much to conume, g_1; and, finally
- consumers from country j, taking a_1^j as given, choose c_1^j and k_2^j.

3.3 An equilibrium

Following the Cole and Kehoe model, we define an equilibrium where market participants choose their actions sequentially, starting with consumers who choose last.

Consumers from each country j take as given the aggregate state of the union, S, their government's decisions, $G^j \equiv (\vartheta^j, z^j, g^j, B^j, B^{j*})$, the union's decision about whether or not to inflate, ϑ^u, and their own decisions regarding savings, k^j, and debt level, b^j. In equilibrium, their choices $C^j \equiv (c^j, k^j, b^j)$ coincide with the aggregate capital and debt levels $(\cdot, K^j, B^j)$. At time t, consumers maximize utility and choose k^j_{t+1} that solves the following condition:

$$\frac{1}{\beta} = (1-\theta^j)\left[f'(k^j_{t+1})E_t\left(a^j_{t+1}\right)] - \delta\right] + 1$$

Furthermore, they act competitively and are risk neutral, so they purchase public debt denominated in common currency, whenever its price is equal to the expected return $1/\beta$:

$$1/\beta = E_t\left(\vartheta^u_{t+1}\right)/q^j_t$$

International bankers also act competitively and are risk neutral. They purchase public debt denominated in foreign currency from country j, whenever its price is equal to the expected return $1/\beta$:

$$1/\beta = E_t\left(z^j_{t+1}\right)/q^{j*}_t$$

For period t, government j chooses in three different moments. First, it announces its vote for inflation, ϑ^j. After knowing the union's decision, ϑ^u, it chooses new public debt $\left(B^j_{t+1}, B^{j*}_{t+1}\right)$. At last, it chooses z^j and g^j. At the beginning of the period, the government anticipates capital accumulation and the price that makes international bankers and local investors indifferent to purchasing public debt. Its optimization problem is

$$\max_{G_t^j} E \sum_{t=0}^{\infty} \beta^t \left[c_t^j + v(g_t^j) \right]$$

$$\begin{aligned} \text{s.t. } \vartheta^j &\in \{\phi, 1\}; \\ g_t^j &\leq \theta \left[a_t^j f(K_t^j) - \delta K_t^j \right] - B_t^{j*}(z_t^j - q_t^{j*}) - B_t^j(\vartheta_t^u - q_t^j); \text{ and} \\ z^j &\in \{0,1\}, \; z^j + \vartheta^u \geq 1. \end{aligned}$$

Finally, for each country j, an equilibrium can be defined as a list of choice variables G_t^j, C_t^j and B_{t+1}^{j*}, an expression for aggregate capital, K_{t+1}^j, and for the prices q_t^{j*} and q_t^j so that:

(i) given S, G_t^j, $q_t^{j*}$and q_t^j: C_t^j solves the consumer's problem;

(ii) given S, C_t^j, $q_{t,s}^{j*}$ and $q_{t,s}^j$: G_t^j solves the government's problem;

(iii) q_t^{j*} and q_t^j solve $1/\beta = E_t[\vartheta_{t+1}^u]/q_t^j = E_t[z_{t+1}^j]/q_t^{j*}$;

(iv) given S, $B_{t+1}^j = b_{t+1}^j$;

(v) given S, $B_{t+1}^{*j} = b_{t+1}^{j*}$; and

(vi) given S, $K_{t+1}^j = k_{t+1}^j$.

4 The Crisis Zone

The crisis zone is defined as the local- (or common-) currency and foreign-currency debt levels for which it is optimal for the government to respond with inflation to a moderate attack, to respond with default to an intense attack and to honor contracts in the absence of an attack. Moreover, if the debt levels are in the crisis zone and inflation can not be implemented during a moderate attack, then to default is the second-best option.

Considering that the payoff for government j, conditional upon decisions z^j and ϑ^u, is denoted by $U(z^j, \vartheta^u)$, then (B_0, B_0^*) are in the crisis zone if the following conditions are satisfied:

$$\begin{aligned}
\zeta^j &\in \Pi_d \Rightarrow U(0,1) \geq \max\{U(1,\phi), U(1,1)\} \\
\zeta^j &\in \Pi_i \Rightarrow U(1,\phi) \geq U(0,1) \geq U(1,1) \\
\zeta^j &\in \Pi_c \cup \Pi_p \Rightarrow U(1,1) \geq \max\{U(0,1), U(1,\phi)\}
\end{aligned}$$

To construct an equilibrium, we consider that local- (or common-) currency debt is fixed at level B_0^j for all t and j. The parameters for the real return on local-(or common-) currency debt after inflation, ϕ, and for the fraction of foreign-currency debt that is rolled over after a moderate attack, φ, are somewhat arbitrary but essential to obtain the crisis zone. Given φ, we can choose ϕ so that inflation is the best response only against a moderate attack. For a different moderate attack, i.e.

a different value of φ, the government may set a different value for ϕ in order to avoid a default on foreign-currency debt. In the numerical exercise we consider only one type of moderate attack, and thus only one value for φ.

Government's preferences also affect the crisis zone. If the government is sufficiently concerned about current public expenditures, then it would rather respond to an attack with default. Conversely, a government sufficiently concerned about consumption of the local-private sector would rather fully pay its debts in all the states. We construct an equilibrium for a more realistic case in which both incentives are present in the crisis zone.

5 Computed Model Results

The numerical exercises make an attempt to outline some conditions under which a country would be better off, in terms of welfare, or by sharing a common monetary policy, or by being on its own, or by following the monetary policy of an anchor country under dollarization. We consider a monetary union between two and three countries and also take into account the two decision processes to inflate described above. Before presenting these results, we describe the difference between the interest rates for local-currency debt and for foreign-curency debt under a common-currency regime and also, show the crisis zone for foreign-currency debt when there are both types of debts and when there is only foreign-currency debt.

5.1 The parameters

The parameters used in the numerical examples portray the Brazilian economy from July 1998 to August 2001. During this period, the average maturity of the Brazilian government domestic debt is in the interval 0.4 to 2.2 years, as shown in Table 5. For the simulations, the maturity length is fixed at one year and the period length is one year as well. The discount factor, β, is given by the yearly yield on the United States government bonds, r, whose value fluctuated between 4.8 and 5 percent. For $r = 0.05$, the discount factor β is 0.95. The tax rate, θ, is set equal to 0.30. The choice of the functional form, $v(g)$, is the same used by Cole and Kehoe [5], $v(g) = \ln(g)$. The results are very sensitive to this specification which, besides determining the coefficient of risk aversion, also defines the relative importance of public expenditure to the private-sector consumption[7]. The production function, $f(k)$, is given by Ak^{λ}, where total factor productivity, A, is equal to one and capital share, λ, is 0.4. The yearly depreciation rate, δ, is equal to 0.05. This drop is equivalent to a net present loss relative to GDP of 1.05 [8]. The parameter α is 0.95, assuming that default causes a permanent drop in productivity of 0.05, as in the Cole and Kehoe model. After a moderate attack, the fraction of the dollar debt that is rolled over, φ, is set as 0.62 and the real return on local- (or common-currency) debt, ϕ, is 0.85. The

[7] We could represent governments more concerned about private goods by replacing the $ln(g)$ with $\frac{ln(g)}{2}$, for example.

[8] We assume $k_{s,t} = k_o, \forall\ t, s$ and that the drop in optimal investment level is equivalent to 1.7. These calculations are available upon request.

corresponding inflation rate, $(1-\phi)/\phi$, is equal to 0.18. The drop in GDP after inflation, α^{ϕ}, is estimated to be 0.998, which is equivalent to a net present loss relative to GDP of 0.03[9].

Furthermore, the probability of default, π^d, and the probability of inflation under local-currency regime, $\pi^i + \pi^p$, are based on the risk premium practiced in the financial market, according to the following expression:

$$\frac{1}{\beta} = \left(1 + r_D^{BR}\right)\left(1 - \pi^d\right) = \left(1 + r_{LC}^{BR}\right)\left[1 - \left(\pi^i + \pi^p\right)(1-\phi)\right]) \tag{4}$$

where r_D^{BR} and r_{LC}^{BR} are yearly real interest rates on Brazilian public debt denominated, respectively, in foreign currency and in local currency. Data for r_{LC}^{BR} are available only since January 2002 and it is around 0.12. It is calculated as the yearly yield on Brazilian Treasury bonds denominated Letras do Tesouro Nacional (LTN) minus the one-year inflation rate. Values for π^d vary between 0.04 and 0.11, which is close to the monthly C-bond spreads for the period under analysis. By solving equation 4, $(\pi^i + \pi^p)$ is evaluated at 0.42. In the simulations, π^d and π^i were fixed at 0.04, and π^p varied from 0 to 0.9. Analogous to π^p, the correlation ρ is somewhat arbitrary and varied between -0.3 and 1 in the simulations.

Table 6 sums up most of the parameters used in the numerical exercises. The last column also indicates the range of the actual economic variables observed in

[9] To estimate the welfare cost of inflation we use Bailey's approximation and the money demand specified as kr^{-a}, where r is the logarithmic annual inflation (see Simonsen and Cysne [17]). We consider k and a equals to 0.04 and 0.6, respectively. These calculations are available upon request.

Brazil during 1998-2001.

5.2 Results

5.2.1 The spread on costs of debts

In the numerical exercices, the expected welfare levels are calculated for each monetary regime, considering the risk-return of the bonds before uncertainty is solved in period t=1. The return on debt denominated in foreign currency is $\left(\frac{1}{\beta E[Z]}\right)$. If its level is below the crisis zone, then the expected value of the government decision variable of whether or not to default, $E[Z]$, is one and its cost is minimum $\left(\frac{1}{\beta}\right)$.If the foreign-debt level is in the crisis zone, its cost depends on the exogenous probability of default, π^d. Analogously, the return on debt denominated in local currency is equal to $\left(\frac{1}{\beta E[\vartheta]}\right)$. If there is no risk of inflation, like under a dollarization regime, then the expected value of the decison variable of whether or not to inflate, $E[\vartheta]$, is one and the cost of local-currency debt is minimum $\left(\frac{1}{\beta}\right)$. If there is risk of inflation and as $E[\vartheta]$ takes lower values because of increasing expected inflation, then the cost of local-currency debt rises.

The probability of inflation falls significantly, for example, when the risk of political inflation is reduced. In addition, it also reduces when there is low correlation of shocks, ρ, among countries in a monetary union with right of veto (see Table 3). In this case, inflation tends to be avoided.

Figure 1 describes the spread on the costs of debts defined as the difference between the returns on local-currency debt and on foreign-currency debt [10]. It shows that, as the probability, π^d, of an intense crisis rises, the spread becomes more negative meaning that the cost of the debt denominated in foreign currency increases relative to the local currency one. For $\pi^d = 4\%$ and with no correlation of external shocks among the two countries of a monetary union with right of veto, the risk of political inflation required to make the local-currency debt more expensive than foreign-currency debt is close to 70%. As the correlation rises, Figure 1 also portrays that the risk of political inflation required to make the spread positive decreases.

5.2.2 The crisis zone

In this section we first describe the crisis zone that Cole and Kehoe [5] constructed for Mexico using the parameters for Brazil. Secondly, we construct the crisis zone for debt denominated in foreign currency when inflation is used to avoid an external default.

In Figure 2, the upper curve portrays what Cole and Kehoe call the *stationary participation constraint* and the lower curve represents what they refer to as the *no-lending continuation condition.* The former constraint is the highest foreign-currency debt level for which it is better not default if the international bankers renew their loans. The latter constraint is the highest foreign-currency debt

[10] To cosntruct this figure, the parameters used are those described for Brazil.

level for which it is better not to default if there is no new lending. For a sufficiently long maturity, the two constraints coincide[11]. The region between both constraints is the crisis zone. Supposing that total Brazilian public debt was only made up of debt denominated in foreign currency, then the Brazilian external debt relative to GDP would be equal to 45 percent with an average maturity in the interval $[0.4, 2.2]$ years. Therefore, the external debt would fall in the crisis zone during the period 1998-2001.

Now, let the local-currency debt, B, be greater than zero and α^{ϕ} close to one. When the price of new foreign-currency debt is zero and the external debt is close to the crisis zone lower bound, it is always better to inflate over a positive B than not to inflate and not to default. In this case, the lower bound of the crisis zone is defined as the highest foreign debt level such that to pay foreign-currency debt and to inflate local-currency debt is better than to default on foreign debt and not to inflate, when the price of new foreign currency debt goes to zero. The upper bound of the crisis zone is the highest foreign debt level such that to pay foreign debt and to inflate local debt is better than to default on foreign debt and not to inflate when the price of new foreign currency debt is β and a crisis never occurs.

In Figure 2, we perturb the crisis zone by considering α^{ϕ} equal to 0.99 and ϕ equal to 0.85. The dotted lines represent the new crisis zone when we consider a local

[11] As from 45 years in our simulation.

debt that can be inflated. The conclusion is, in case of no rollover of foreign-currency debt, then a higher external debt level is required for default to take place.

5.2.3 The welfare levels under alternative monetary regimes

In this section, we establish some numerical facts that follow from the evaluation of welfare levels under alternative monetary regimes. We show some conditions under which to share a common monetary policy decision is better than to maintain a local-currency or a dollarization regime. This choice depends on the risk of political inflation on the local- (or common-) currency, π^p, and on the correlation of external shocks over the foreign-currency debt, ρ, that each member country of a monetary union is subject to. This correlation determines the likelihood of suboptimal states u (moderate attack with veto), w (intense attack with no default) and p (political inflation) occurring.

Considering a two-identical-country monetary union, three regions emerge from the plane made up of the external shocks correlation, ρ, and the risk of political inflation, π^p. One of them is indicated as *Dollar* which means that the welfare level of dollarization is higher than under common-currency and local-currency regimes for the specific values of π^p and ρ that cover this region. In the second region, denoted by *Common Currency*, the common-currency regime is better in terms of welfare than the other two. The third region, *Local Currency*, the welfare of local-currency regime is the highest compared to the other two monetary regimes. According to the evaluation of the welfare levels, we describe five numerical facts. Numerical facts 1 to 4, consider that each member of the monetary union has the right of veto over the union's decision to inflate. Numerical fact 5 takes into account that each country j has some political influence over the union's central bank decision to inflate.

Numerical fact 1: In a model with local currency, the bigger the risk of political inflation, the larger the region where dollarization maximizes welfare.

Figure 3 shows that the Dollar region spreads out the higher the risk of political inflation. If the risk of political inflation is high, close to 0.9 in our exercise, then to keep the economy dollarized is the best choice, independently of correlation. Conversely, when the correlation ρ is low and there is no risk of political inflation, $\pi^p = 0$, then investors have full confidence that the government will not inflate for political reasons and so, it is better not to give up monetary autonomy.

Numerical Fact 2: In a model with common currency, the larger the correlation of external shocks among the member countries, the larger the region where common currency maximizes welfare.

For intermediate levels of π^p, Figure 3 shows that the correlation helps to define the monetary regime. The higher the correlation of shocks among two member countries, the greater the interval of risk of political inflation for which a common currency provides the highest welfare level.

Numerical Fact 3: The minimum correlation required for the common-currency regime to be optimal increases with the number of participants with the right of veto.

Figure 4 compares the results for the common-currency regime, considering two and three countries. Adding a third country with the right of veto makes inflation less likely. The Common Currency region shrinks and moves towards higher values of external-shocks correlation.

Numerical Fact 4: Suppose a country is to decide either to join a monetary union, or to dollarize with a third country, or to remain under local-currency regime. The range for the parameter ρ in which the common-currency regime is optimal increases over the dollar region and decreases over the local-currency region as the risk of political inflation in the partner country decreases.

By relaxing the hypothesis of identical countries, we analyze the incentives for country A to join a monetary union with country B, whose risk of political inflation is fixed at π^{pB}. Figure 5 reports results for two different values of π^{pB}: 0.7 and 0. The low risk of political inflation in country B makes inflation in the union less likely, since country B votes for inflation only if it suffers a moderate attack. If country A is considering to share its monetary policy with country B, then it will have less chance to inflate under this monetary regime. Accordingly, the common-currency regime increases monetary discipline and the Common Currency region increases over the Dollar region, while it decreases over the Local Currency region. On the other hand, if the risk of political inflation of country B is high, the common-currency becomes preferable to lower levels of external-shocks correlation.

Numerical Fact 5: For high levels of the risk of political inflation in a country, the region where dollarization is preferred by such a country increases over the area where common currency is preferred as the probability of the country influencing the central bank of the monetary union increases.

Instead of having the right of veto, we assume that country A has some political influence over the union's central bank, given by probability, pw^A. The higher pw^A is, the stronger is its influence on the union's central bank. In Figure 6, π^{pB} is fixed at 0.7 and pw^A takes three different values: 0, 0.4 and 0.8.[12] For high levels of the risk of political inflation, $\pi^{pA} > 0.7$ and correlations below 0.55, country A would rather dollarize than join country B in a monetary union. For correlations of external shocks a little higher than 0.55, country A shares its monetary policy with country B for low values of pw^A. This way, the

[12] Over the line that separates the common-currency and the local-currency regions, welfare is the same for both regimes. This locus does not depend on the value of pw. Thus, if the government is indifferent to both regimes, it will be indifferent to pw.

common-currency regime provides some monetary discipline, without having to dollarize and to discharge some ability to inflate.

6 Monetary Regimes for Argentina and Brazil

The results obtained with the numerical exercises are aligned with the preference for dollarization by Argentina and Brazil in the early 1990s, when to reduce inflation was the main objective of monetary policy. Public confidence in both currencies was very low, because of the high risk of political inflation in both economies.

The results also make it possible to appraise why different monetary regimes were adopted in Brazil and Argentina between 1998 and 2001. After the Russian default in August 1998, Argentina maintained the currency-board regime, which is similar to what we describe as dollarization, and defaulted on its external debt in the end of 2001. Brazil adopted a floating exchange rate regime in January 1999, which resembles our local currency model, and led to a moderate inflation in Brazil as of 1999.

One reason for the different choices of monetary regimes in Argentina and Brazil after the speculative attack they suffered in 1998 is a higher risk of political inflation in Argentina than in Brazil. According to Figure 3, Argentina's welfare level would be located in the Dollar region, which is characterized by high levels of risk of political inflation, while Brazil would be placed in the Local Currency region, with a risk of political inflation smaller than the Argentine one.

A higher risk of political inflation in Argentina can be explained by difficulties in controlling public expenditure. At the time of our analysis, each province in Argentina had an incentive to maximize local spending without a commitment to sustain aggregate expenditure. In Brazil, on the contrary, the institutional environment favored relatively more public expenditure control. The Fiscal Responsibility Law, from May 2000, is an example of political efforts towards ensuring the public-finance sustainability in Brazil.

Another reason for the different choices of monetary regimes in Argentina and Brazil after 1998 concerns government preferences, which are captured by the utility function $v(g)$. In the numerical exercises $v(g) = \ln(g)$, which implies a coefficient of relative risk aversion equal to one. In order to evaluate the effect of this coefficient on the welfare level under different monetary regimes, we employ a different specification for the function $v(g)$ for Argentina. The new function is $g^{0.01}$, whose coefficient of relative risk aversion is 0.99 instead of one. The other parameters used in the simulations for Argentina are the same as the ones for Brazil, except for some changes. The local-currency debt relative to GDP is about five percent of GDP between 1998 and 2001, however $\frac{B}{GDP}$ is parameterized as 0.5 to increase local-currency regime payoff. The risk of political inflation is fixed at 0.53,the real return on local-currency debt after inflation, ϕ, is 0.5 and the tax rate, θ, is 0.25.

With such parameters, the government is indifferent between local-currency regime and dollarization. If the coefficient of relative risk aversion is less than 0.99, then dollarization is preferred. If it is greater than 0.99, then local-currency regime is chosen. Thus, the region where dollarization is preferable grows with the reduction in the risk aversion.

7 Conclusions and Extensions

This paper discusses the monetary regimes for countries heavily dependent on international lending and subject to a speculative attack on its debt denominated in foreign currency. Our analysis shows that to share a common monetary policy might provide a better default technology than to be on its own or to dollarize. This aspect of the costs and benefits of a monetary union had not been appraised before and we hope to be contributing to the findings of Mundell [13], McKinnon [12] and Kenen [11].

The numerical exercises show that dollarization gives higher welfare levels, than the local-currency and the common-currency regimes, to economies characterized by high risk of political inflation. However, when the risk of political inflation is at an intermediate level and the correlation of external shocks among a group of two or three countries is high, then to share a common monetary policy increases confidence in the currency, without losing inflation as an additional instrument to smooth adverse external shocks. Local-currency regime dominates the other two regimes, when external shocks are uncorrelated and the room for political pressure is mild.

Traditionally, research on monetary union arrangements do not address the political inflation or default risk as variables of decision on adopting a common currency. Such issues should be taken into account by economies that have weak currencies and a significant risk of default on their foreign-currency debt. Accordingly, this paper could give some criteria for this type of decision.

In further extensions, our model provides a good setup to analyze in more detail a monetary union between a country with a credible currency, similar to Germany, and another with a weaker one, like Greece. This type of monetary union would benefit Germany by means of an increase in its trade flows with Greece. If Greece leaves the union in order to default on its external debt or to inflate its own currency, a fall in its productivity is reflected in a contraction of its GDP as well as of its partner country in the union. The economic activity of Germany would be adversely affected, because of its reduced trade flow with Greece.

To take into account the effects on productivity that result from the formation of a monetary union, we have to change our model in a not very difficult way. The mechanism of a fall in productivity of a member country, which is suffering a speculative attack, spilling over to the productivity of its partner country would be further aggravated by an exit from the union. To model this mechanism would require a change towards a Mundellian framework with fiscal federalism.

In our original model, we look only at the financial aspect of a monetary union. In this respect, the country with a more credible currency is not interested in having more countries joining the monetary zone. Therefore, there is also no incentive for fiscal federalism. On the other hand, in a more Mundellian framework, where countries gain from trade if they are associated with each other under a monetary union, the situation changes. The strongest country benefits from the international trade flow within the union and is willing to cover some of the fiscal gaps during the crisis of the weaker country. In exchange, the strongest country requires more fiscal discipline from the weaker one. Therefore, fiscal federalism might increase the welfare of the monetary union. To expand our model in this direction would need to include productivity gains associated to the increasing trade flows within the union.

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8 Appendix A

The following table shows the events that might occur in a monetary union between two identical countries $(A + B)$, given no occurrence of an intense shock:

Event	A - Vote	Decision	State	Symmetry	Probability
(s^A, s^B)	ϑ^A	ϑ^u	$s^{A,u}$	Attacks	$Prob((s^A, s^B))$
(c, i)	1	1	c	n	$\pi_A^c \pi_B^i (1-\rho)\mu$
(c, p)	1	1	c	y	$\pi_A^c \pi_B^p (1+\rho)\mu$
(c, c)	1	1	c	y	$\pi_A^c \pi_B^c (1+\rho)\mu$
(p, c)	ϕ	1	c	y	$\pi_A^p \pi_B^c (1+\rho)\mu$
(i, c)	ϕ	1	u	n	$\pi_A^i \pi_B^c (1-\rho)\mu$
(i, p)	ϕ	ϕ	i	n	$\pi_A^i \pi_B^p (1-\rho)\mu$
(i, i)	ϕ	ϕ	i	y	$\pi_A^i \pi_B^i (1+\rho)\mu$
(p, p)	ϕ	ϕ	p	y	$\pi_A^p \pi_B^p (1+\rho)\mu$
(p, i)	ϕ	ϕ	p	n	$\pi_A^p \pi_B^i (1-\rho)\mu$

given that $\binom{P_{NS}}{P_S} \equiv \binom{\pi_A^c \pi_B^i + \pi_A^i \pi_B^c + \pi_A^i \pi_B^p + \pi_A^p \pi_B^i}{\pi_A^c \pi_B^p + \pi_A^c \pi_B^c + \pi_A^i \pi_B^i + \pi_A^p \pi_B^p + \pi_A^p \pi_B^c}$, *and* $\mu \equiv \frac{P_{NS}+P_S}{P_{NS}+P_S+\rho(P_S-P_{NS})}$.

If $\rho \in [-1, 1] \Rightarrow P_{NS} + P_S + \rho(P_S - P_{NS}) \geq 0$, then $\mu \geq 0$.

$$P_{NS} + P_S = P_{NS}\,(1-\rho)\,\mu + P_S\,(1+\rho)\,\mu$$

$$P_{NS} + P_S = \pi_A^c\,(\pi_B^i + \pi_B^c + \pi_B^p) + \pi_A^i\,(\pi_B^c + \pi_B^i + \pi_B^p) + \pi_A^p\,(\pi_B^i + \pi_B^p + \pi_B^c)$$

$$P_{NS} + P_S = (\pi_B^i + \pi_B^c + \pi_B^p)\,(\pi_A^c + \pi_A^i + \pi_A^p)$$

$$P_{NS} + P_S = \left(1-\pi^d\right)\left(1-\pi^d\right) = \left(1-\pi^d\right)^2$$

$$P_S - P_{NS} = P_{NS} + P_S - 2P_{NS} = \left(1-\pi^d\right)^2 - 2P_{NS}$$

$$P_S - P_{NS} = \left(1-\pi^d\right)^2 - 2\pi_B^i\,(\pi_A^c + \pi_A^p) - 2\pi_A^i\,(\pi_B^c + \pi_B^p)$$

$$P_S - P_{NS} = \left(1-\pi^d\right)^2 - 2\pi_B^i\left(1-\pi^d-\pi_A^i\right) - 2\pi_A^i\left(1-\pi^d-\pi_B^i\right)$$

$$\pi_A^i = \pi_B^i = \pi^i \Rightarrow P_S - P_{NS} = \left(1-\pi^d\right)^2 - 4\pi^i\left(1-\pi^d\right) + \left(2\pi^i\right)^2$$

$$P_S - P_{NS} = \left[\left(1-\pi^d\right) - 2\pi^i\right]^2 > 0$$

$$\mu = \frac{\left(1-\pi^d\right)^2}{\left(1-\pi^d\right)^2 + \rho\left[\left(1-\pi^d\right)-2\pi^i\right]^2}.$$

If ρ value is -1 and an intense attack does not occur, then there is no symmetrical attack. If ρ is 0, then the shocks occur independently. If ρ is 1, then there is no asymmetrical moderate attack.

Table 3 sums up the five relevant events (out of 16) for member A, given $n = 2$.

If $n = 3$, we have:

s_u^A	Probability
d	π^d
c	$\pi^c \left(\pi^d\right)^2 + 2\pi^c\pi^d\pi^i + 4\pi^c\pi^p\pi^d + 2\pi^d \left(\pi^c\right)^2 + 2\pi^d \left(\pi^p\right)^2 + 2\pi^p\pi^d\pi^i + \pi^p \left(\pi^d\right)^2 + ...$
	$...(1-\rho)\,\mu \left[\pi^c \left(\pi^i\right)^2 + 2\pi^i \left(\pi^c\right)^2 + 4\pi^c\pi^p\pi^i\right] + (1+\rho)\,\mu \left[3\pi^c \left(\pi^p\right)^2 + 3\pi^p \left(\pi^c\right)^2 + \left(\pi^c\right)^3\right]$
u	$2\pi^c\pi^d\pi^i + \pi^i \left(\pi^d\right)^2 + 2\pi^p\pi^d\pi^i + 2\pi^d \left(\pi^i\right)^2 + (1-\rho)\,\mu \left[2\pi^c \left(\pi^i\right)^2 + \pi^i \left(\pi^c\right)^2 + 2\pi^c\pi^p\pi^i\right]$
i	$(1-\rho)\,\mu \left[2\pi^p \left(\pi^i\right)^2 + \pi^i \left(\pi^p\right)^2\right] + (1+\rho)\,\mu \left(\pi^i\right)^3$
p	$(1-\rho)\,\mu \left[\pi^p \left(\pi^i\right)^2 + 2\pi^i \left(\pi^p\right)^2\right] + (1+\rho)\,\mu \left(\pi^p\right)^3$

given that $\binom{P_{NS}}{P_S} = \binom{3\pi^c\left(\pi^i\right)^2+6\pi^c\pi^p\pi^i+3\pi^i(\pi^c)^2+3\pi^p\left(\pi^i\right)^2+3\pi^i(\pi^p)^2}{(\pi^p)^3+(\pi^c)^3+(\pi^i)^3+3\pi^c(\pi^p)^2+3\pi^p(\pi^c)^2}$.

Tables and Figures

Table 1: Monetary Regimes Trade-offs

Regime	Flexibility	Credibility
Local Currency	total	low
Common Currency	partial	medium
Dollarization	null	high

Table 2: States Under Local Currency in the Crisis Zone

States	Shocks	Actions
c	none	respect contracts
p	political inflation	inflation
i	moderate attack	inflation
d	intense attack	default

Table 3: Monetary Union Between Members With Right of Veto (n=2)

s_u^A	Probability
d	π^d
c	$\pi^d(\pi^c+\pi^p)+\pi^c(1+\rho)\mu[2\pi^p+\pi^c]+(1-\rho)\mu[\pi^c\pi^i]$
u	$\pi^i\left(\pi^d+\pi^c(1-\rho)\mu\right)$
i	$\pi^i\mu(\pi^p(1-\rho)+\pi^i(1+\rho))$
p	$\pi^p\mu(\pi^p(1+\rho)+\pi^i(1-\rho))$
where $\mu\equiv\frac{\left(1-\pi^d\right)^2}{\left(1-\pi^d\right)^2+\rho(1-\pi^d-2\pi^i)^2}$.	

Table 4: Monetary Union Between Members With Political Influence

s^A	Probability Under Common Currency (n=2)	(n=1)
d	$pw^A\cdot\pi^d+(1-pw^A)\cdot[\pi^d\pi^d+\pi^d\pi^c]$	π^d
c	$pw^A\cdot\pi^c+(1-pw^A)\cdot\{\pi^d(\pi^c+\pi^p)+\pi^c(1+\rho)\mu[\pi^p+\pi^c]\}$	π^c
u	$pw^A\cdot 0+(1-pw^A)\cdot[\pi^i(\pi^d+\pi^c(1-\rho)\mu)]$	0
w	$pw^A\cdot 0+(1-pw^A)\cdot[\pi^i\pi^d+\pi^p\pi^d]$	0
i	$pw^A\cdot\pi^i+(1-pw^A)\cdot[\pi^i\mu(\pi^p(1-\rho)+\pi^i(1+\rho))]$	π^i
p	$pw^A\cdot\pi^p+(1-pw^A)\cdot[\mu([\pi^p\pi^p+\pi^c\pi^p](1+\rho)+(1-\rho)[\pi^p\pi^i+\pi^c\pi^i])]$	π^p

Table 5: Brazilian Public Debt Length (Years)

Length	Model	Brazil (98-01)
Average Maturity	1	[0.4 , 2.2]
Average Duration	1	[0.2 , 0.9]

Table 6: Economy in the Crisis Zone

Variables relative to GDP	Model (t = 0)	Brazil (98-01)
External debt	$\frac{(B^*)}{f(K)} = 45$	[31 , 45]
External public debt	$\frac{(B^*)}{f(K)} = 45$	[9 , 24]
Local currency public debt	$\frac{(B)}{f(K)} = 30$	[27 , 31]
Capital outflow	$\frac{B^*(1-q^*)}{f(K)} = 4$	-
Investment	$\frac{\delta K}{f(K)} = 16$	[20 , 22]
Private consumption	$\frac{c}{f(K)} = 60$	[61 , 62]
Public expenditure	$\frac{g}{f(K)} = 20$	[19 , 19]

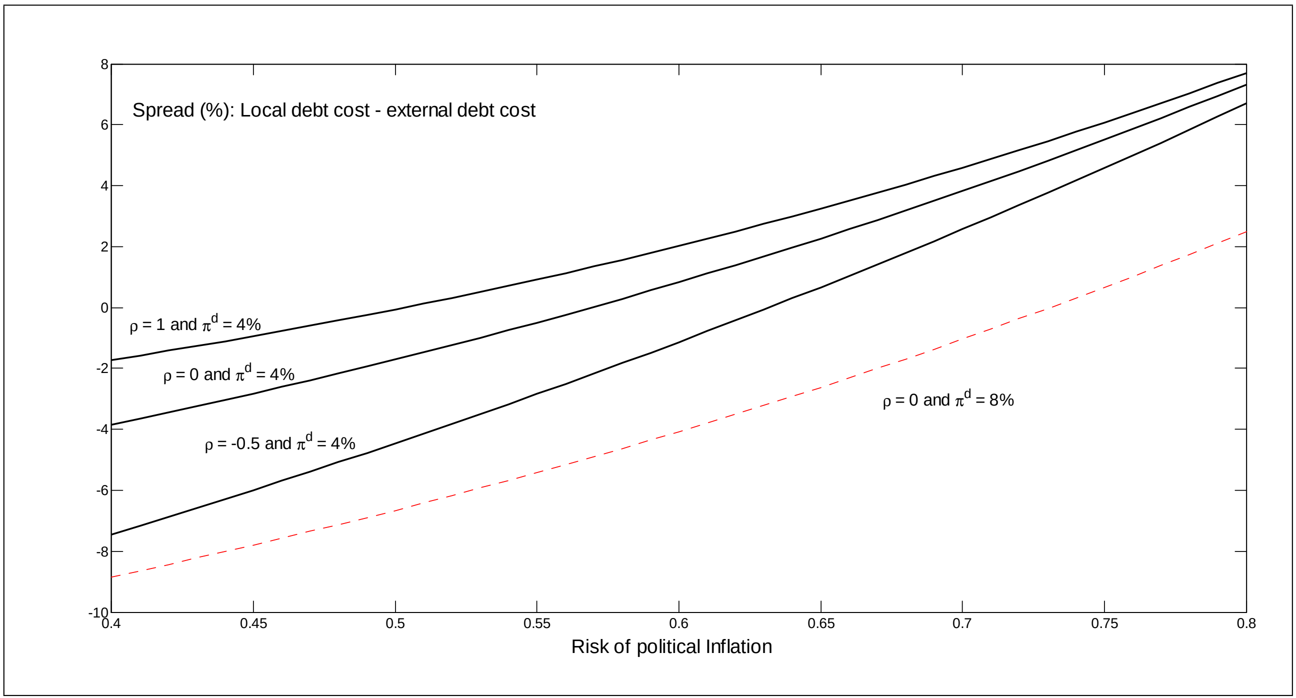

Figure 1: Spread on debt costs

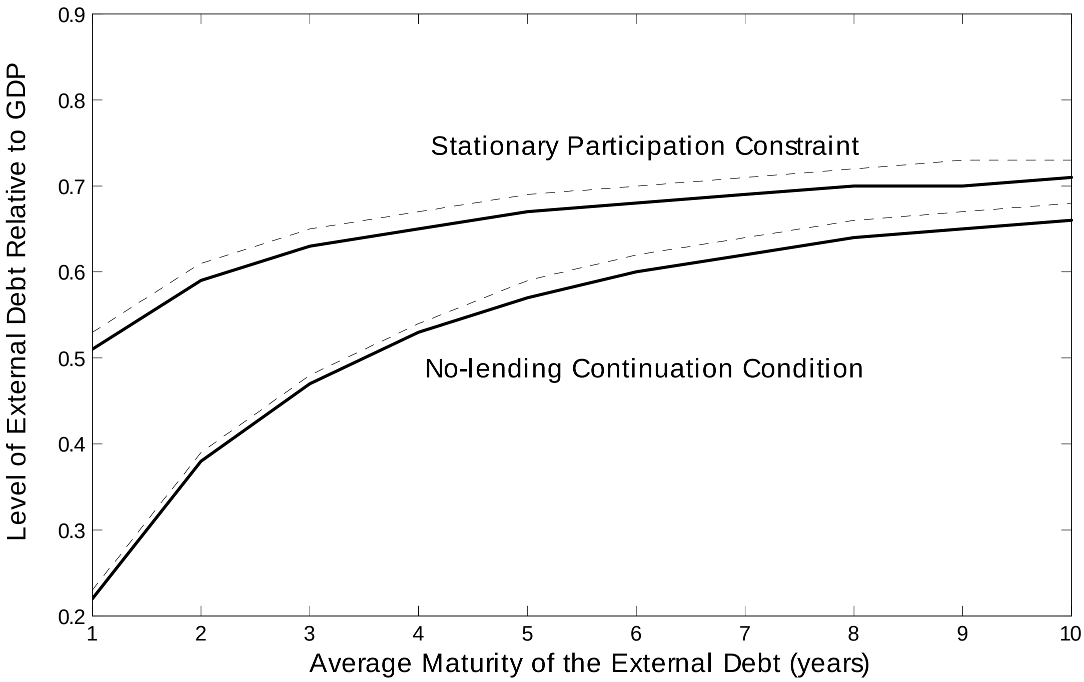

Figure 2: The Debt Crisis Zone

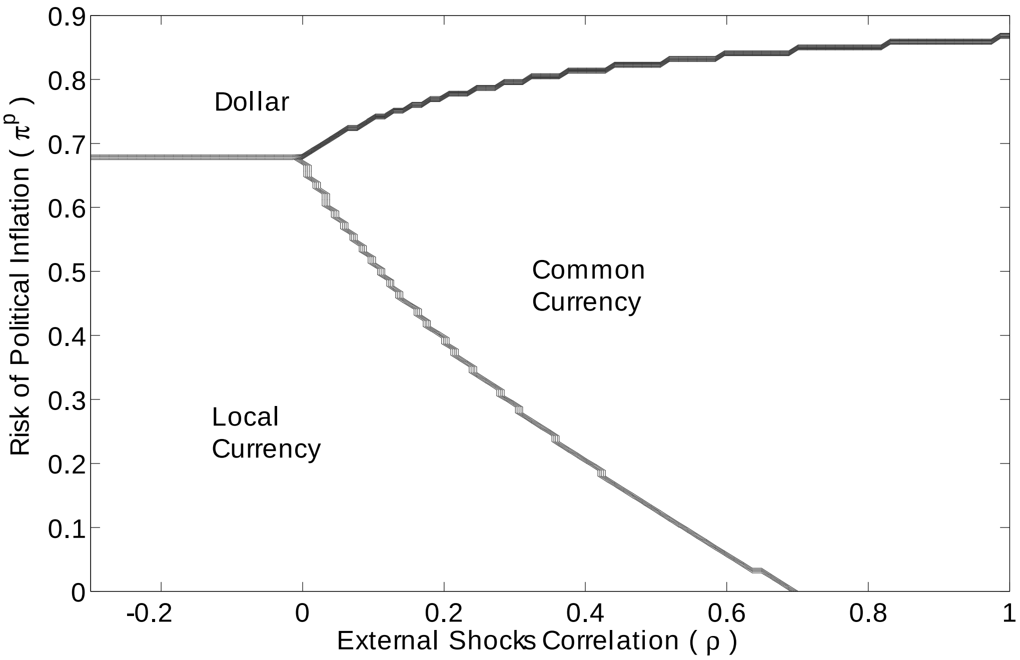

Figure 3: Optimal Monetary Regime (Veto allowed, n = 2)

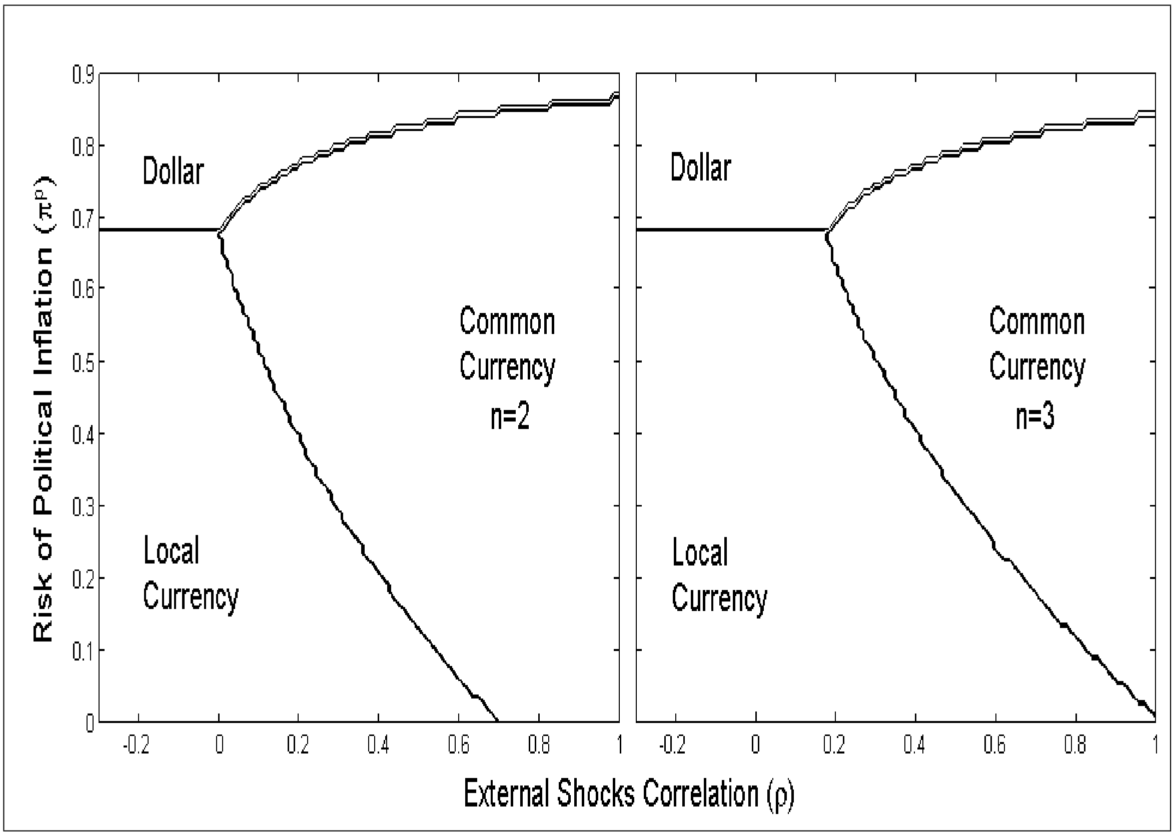

Figure 4: Optimal Monetary Regime (veto allowed, n=2 and n=3)

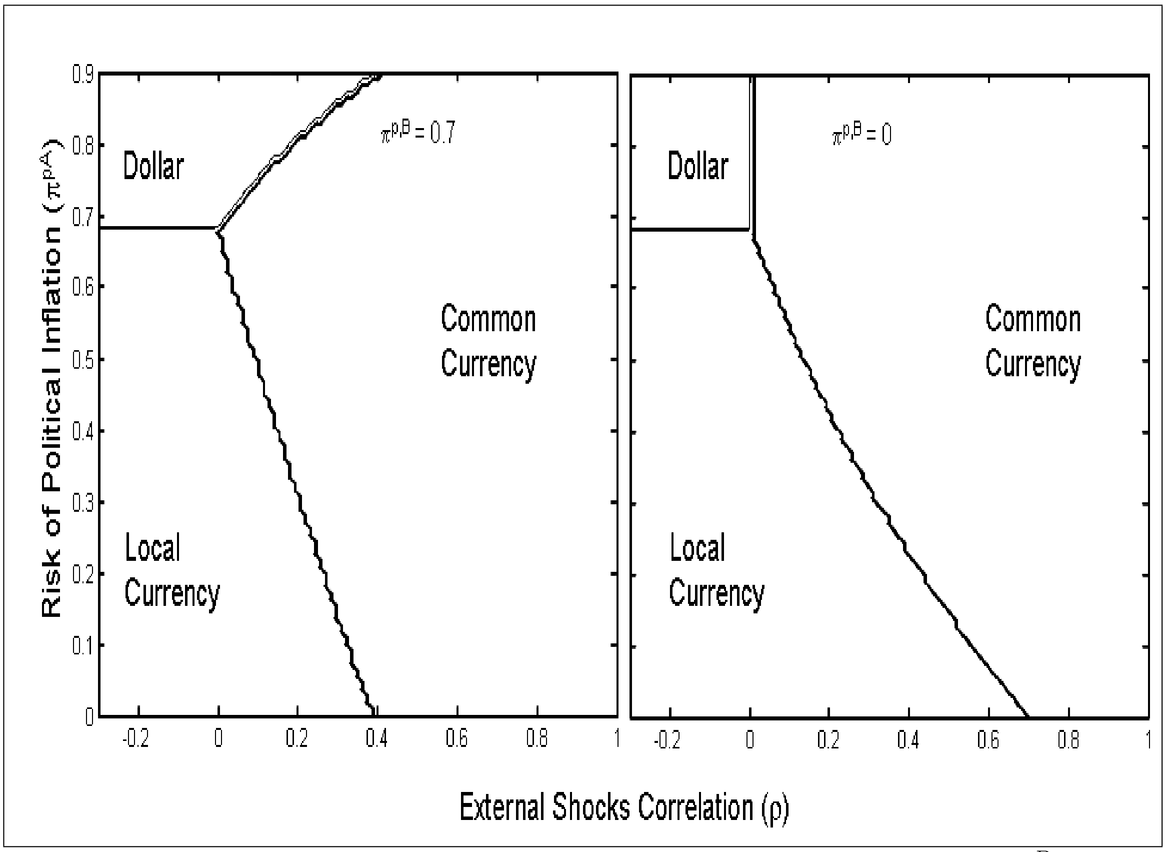

Figure 5: Optimal Monetary Regime (n=2, veto allowed, Different π^{pB})

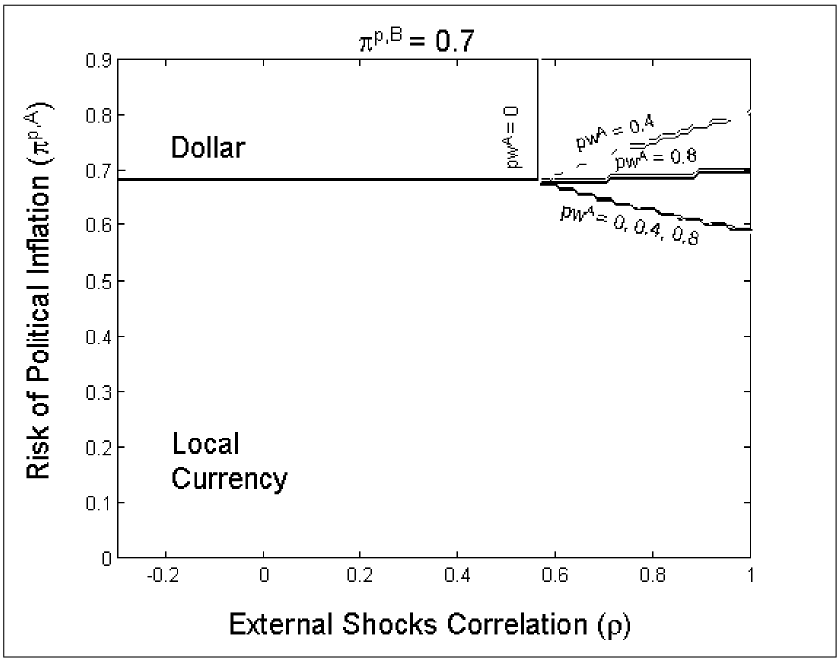

Figure 6: Monetary union given different pw