The Costs of Losing Monetary Independence: The Case of Mexico[*]

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1 Introduction

The most common argument advanced in favor of fixed exchange rates is that they promote economic and financial integration and impose some degree of monetary discipline on the participating countries. Countries are disciplined in the sense that it is more difficult for them to unilaterally undertake expansionary monetary policies in a fixed exchange rate system. The proposal to "dollarize" several emerging market economies, and Mexico in particular, is an extreme version of this. By adopting the U.S. dollar as the national currency, these economies would not only impose a fixed exchange rate but would forego any chance of adopting independent monetary policies that are inconsistent with that exchange rate. The conjectured benefits are many, but much of the argument in favor of policies like these hinges on the prospect that this would eliminate an inflationary bias in Mexican monetary policy. Of course, it is well recognized that there may be costs to such a policy as well. By joining a currency area, a country would lose monetary independence. This loss of monetary independence means that the country can no longer use the instruments of monetary policy to adjust to internal or external shocks. The conventional wisdom that emerges from discussions of "optimal currency areas" is that the cost of losing monetary independence is going to be larger the more asymmetric are the shocks that affect the participating countries.

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The implication of these standard arguments is that, in deciding whether to join a currency area, any country faces a trade-off. On the one hand, the monetary discipline argument seems to favor the adoption of a unique currency for inflation prone countries. On the other, the loss of monetary independence suggests that the adoption of a unique currency could be costly. What are the implications of these considerations for the issue at hand - whether Mexico would benefit from dollarization?

In this paper we address this question by constructing a simple artificial economy that can provide a quantitative assessment of some of the costs and benefits of dollarization for Mexico. We describe a two-country model that is calibrated to features of the U.S. and Mexican data. We use it to quantify some of the net costs and benefits of dollarization. We do this by making some rather strong assumptions. First, we characterize how Mexican monetary policy would respond to real shocks if they were following an optimal and time-consistent monetary policy, taking U.S. monetary policy as given. The ability to react this way is what Mexico would lose if they adopted U.S. currency and hence U.S. monetary policy. In the theory of optimal currency areas this is one major cost of joining. We also quantify the welfare consequences of reducing long-term inflation. This is the monetary discipline that is typically regarded as welfare improving for the country.

The results of our analysis cast doubt on the view that the replacement of the Peso with the U.S. currency would be welfare improving for Mexico. What may be surprising is that this pessimistic conclusion does not stem from the fact that Mexico would lose the ability to react optimally to shocks. There are costs associated with this loss but they are quite small even under the most extreme assumptions about the asymmetry of the shocks. Even more costly, in our framework, is the part that is typically viewed as welfare improving for the country: the reduction in long-term inflation. We show that a higher inflation rate could actually be welfare improving for Mexico and that this is what a benevolent policy maker would choose under the assumptions that characterize our analytical framework.

The intuition that underlies the latter result is quite simple. A higher inflation rate translates into a higher interest rate which reduces the demand for foreign imports. This, in turn, implies an appreciation of the nominal and, most importantly, the real exchange rate. The appreciation of the real exchange rate implies that foreign imports are less expensive. Having the external constraint of a balanced trade account (in the long run this must be the case), a lower price of foreign imports allows the country to import more in real terms. If imports are intermediate goods that are not easily substitutable with domestic inputs, the higher imports of these intermediate goods allows the country to increase production and welfare. We find that the greater the complementarity between domestic and foreign inputs, the higher is the optimal inflation rate.

In reaching the conclusion that the reduction in inflation is not welfare improving, we not only assume that the Mexican monetary authorities behave optimally, we also neglect some of the subsidiary arguments about the benefits of monetary discipline. Chief among these is the assumption that monetary discipline also induces a fiscal discipline.

According to this view, the reason some countries like Mexico have high rates of inflation is because they cannot finance their fiscal expenditures with taxes. Limiting the ability of these countries to use money to support their fiscal policies constrains them to have a more disciplined fiscal policy. In other words, monetary discipline induces fiscal discipline.

There are two problems with this argument. First, *a priori* a reduction in fiscal spending is not necessarily welfare improving. Second, the evidence does not clearly support the notion that monetary discipline promotes fiscal discipline. The experience of the European countries that joined EMU shows that monetary discipline is not a sufficient condition for fiscal discipline. As is well known, the creation of the European Monetary Union resulted in a convergence of the country members to a lower inflation rate. But, those countries that were initially considered to have low fiscal discipline are still far away from the initial targets of the Maastricht Treaty. The participation in a monetary union may actually make fiscal imbalance easier to manage as the government has better access to foreign investors. Further, the evidence of Argentina and Brazil does not seem to support the notion that currency discipline leads to fiscal discipline

In this paper we describe a two country world where both countries are technologically and financially integrated. The production activity in each country requires two inputs: one domestically produced and the other imported from the other country. Each country is affected by a productivity shock. Agents own financial assets in the form of bank deposits. Part of these assets are in domestic banks, and therefore, they are denominated in domestic currency, and part are in foreign banks and denominated in foreign currency. Firms finance the purchase of the intermediate input by borrowing from domestic banks at the market interest rate. In the model, monetary policy interventions in both countries have liquidity effects, that is, a monetary expansion induces a fall in the domestic nominal interest rate. The fall in the nominal interest rate, then, has an expansionary effect in the real sector of the economy. To make sure that monetary policy interventions have liquidity effects, we have to impose some rigidity in the ability of the households to readjust their portfolio. We assume that deposits can be adjusted at any moment, but there is a cost for doing this. We interpret this cost as the losses associated with an early liquidation of financial assets.

In this framework we study the optimal and time-consistent monetary policy in country 1 (Mexico), when country 2 (United States) follows a certain exogenous monetary policy. Therefore, we are assuming that the U.S. monetary policy does not react optimally to changes in Mexico. We justify this assumption by the fact that Mexico is small in economic terms, relative to the U.S. economy. The Mexican monetary authority is assumed to maximize the welfare of Mexican consumers using the instruments of monetary policy. We assume there is no commitment technology so the policy maker cannot credibly commit to future policies. Therefore, the type of policies we analyze must be time-consistent.

In this environment the policy maker is able to influence the real exchange rate by using the instruments of monetary policy. By implementing a contractionary policy, the policy maker can increase the nominal interest rate which reduces the demand for foreign imports and attracts foreign financial investments. The reduction in imports and the inflow of foreign investments, in turn, induces an appreciation of both the nominal and real exchange rate. With the appreciation of the real exchange rate, the cost of foreign imports is cheaper (the country needs to give up less domestic production to pay for the foreign imports) and this allows for an increase in production and consumption. Agents in the economy anticipate that the policy maker acts in this way. Therefore, they form expectation of higher future nominal interest rates that will then be fulfilled by the monetary policy that will be implemented in the future. The equilibrium will be characterized by a higher nominal interest rate. In the long-run, a higher nominal interest rate requires a higher rate of inflation (the Fisher effect), and the long-run equilibrium will be characterized by an inflationary bias. The key assumption that leads to this result is that imported inputs are complements in production.

The optimal policy will also react to technology shocks in the U.S. and Mexico, and to monetary shocks in the U.S. The dollarization of the Mexican economy will then imply that the policy maker will no longer use its monetary instruments to optimally adjust to these shocks. However, as claimed above, we find that the gains of using monetary instruments to optimally adjust to these shocks are very small, much smaller than the gains that are realized from being able to use monetary policy to set the long term inflation differential at an optimal level.

Finally, we would like to point out that the assumption that the U.S. is not reacting optimally to the policy adopted in Mexico is crucial for the results. If we assume that the two countries are setting their monetary policy competitively (either in a Stackelberg scheme or in a Nash scheme), then the cooperative creation of a currency area might eventually be optimal for both countries. This is because the reduction in inflation is not only unilateral, but both countries will have lower interest rates.

2 Model description

Consider a two-country economy. In the first country there is a continuum of households of total measure 1 and in the second country there is a continuum of households of total measure μ. Therefore, μ represents the population size of country 2 relative to the population size of country 1. Households maximize the expected life time utility $E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$, where the period utility is a function of consumption c_t and β is the discount factor.

In each country there is also a continuum of firms. For simplicity we assume that each firm employs one household-worker and runs the following production technology:

$$y_1 = A_1 x_1^{\gamma} \qquad x_1 = \left(x_{11}^{\epsilon} + \phi_1 x_{12}^{\epsilon} \right)^{\frac{1}{\epsilon}} \tag{1}$$

where A_1 is the technology level of country 1, x_{11} is an intermediate input produced by firms in country 1, and x_{12} is an intermediate input produced in country 2 (import). The same technology, with parameter ϕ_2 and technology level A_2, is used in country 2. We assume that $\nu < 1$ and $\epsilon < \nu$.

Firms need to finance the purchase of these inputs by borrowing from a financial intermediary. The nominal interest rate on loans in country 1 is R_1 and the interest rate in country 2 is R_2. Denote by e the nominal exchange rate (units of currency of country 1 to purchase one unit of currency of country 2). The real exchange rate is denoted by $\bar{e}$ and is equal to $e \cdot P_2/P_1$, where P_1 is the nominal price in country 1 and P_2 is the nominal price in country 2 (both expressed in their respective currency). After noting that the price of the final goods must be equal to the price of the intermediate goods produced at home, the loan contracted by a firm in country 1 is equal to $P_1(x_{11} + \bar{e}x_{12})$ and the loan contracted by a firm in country 2 is $P_2(x_{22} + x_{21}/\bar{e})$. The optimization problem solved by a firm in country 1 is:

$$\max_{x_{11},x_{12}} \left\{ A_1 x_1^{\nu} - (x_{11} + \bar{e} \cdot x_{12})(1 + R_1) \right\} \tag{2}$$

with solution:

$$x_{11} = \left(\frac{\nu A_1}{1 + R_1} \right)^{\frac{1}{1-\nu}} \left[1 + \phi_1 \left(\frac{\phi_1}{\bar{e}} \right)^{\frac{\epsilon}{1-\epsilon}} \right]^{\frac{\nu-\epsilon}{\epsilon(1-\nu)}} \tag{3}$$

$$x_{12} = \left(\frac{\phi_1}{\bar{e}} \right)^{\frac{1}{1-\epsilon}} x_{11} \tag{4}$$

The demand of the domestic and foreign inputs depend positively on the aggregate shock, and negatively on the domestic interest rate. Moreover, if $\nu > \epsilon$, the real exchange rate has a negative impact on both inputs. Therefore, a policy that induces an appreciation of the real exchange rate, that is, a fall in $\bar{e}$, has an expansionary effect in country 1.

The profits of firms in country 1 are denoted by π_1. These profits are distributed to the households at the end of the period.

Households own financial assets in domestic and foreign currency. Financial assets in foreign currency are held in foreign banks, and financial assets in domestic currency are held in home banks. From now on we will call financial assets deposits. The portfolio of deposits can be adjusted at any moment, but there is a cost for doing so. For domestic deposits, the adjustment cost (expressed in domestic currency) is $P_1\tau^D(d_{11}, d'_{11})$. For foreign deposits, the adjustment cost (expressed in foreign currency) is $P_2\tau^F(d_{12}, d'_{12})$. In addition to deposits, households in country 1 also own liquid assets used for transactional purposes as they face the following cash-in-advance constraint:

$$P_1(c_1 + \tau^D(d_{11}, d'_{11}) + \bar{e} \cdot \tau^F(d_{12}, d'_{12})) = a'_1 - d'_{11} - e \cdot d'_{12} \tag{5}$$

where a_1 denotes the total financial assets owned by an individual household (denominated in domestic currency) after the government transfers. Government transfers will be specified below. Part of these assets are held in domestic deposits, d'_{11}, and part in foreign deposits, d'_{12}. Because foreign deposits are denominated in foreign currency, we have converted them in domestic currency using the nominal exchange rate e. The cost to adjust the deposits held in country 2 is paid in foreign currency, and therefore, is multiplied by the real exchange rate.

3 The tools of monetary policy and the objective of the policy maker

In each period households receive a monetary transfer in the form of bank deposits. The monetary transfer is denoted by T and it is equal to gM where M is the pre-transfer nominal stock of domestic currency in circulation (money) and g is the growth rate of domestic currency. Because transfers are in the form of bank deposits, by increasing these transfers the monetary authority increases the liquidity available to the intermediaries to make loans. By limiting the abilities of households to readjust their portfolio, the increase in liquidity induces a fall in the nominal interest rate.

The way in which the monetary authorities conduct their policies differ in the two countries. In country 2, we assume that the monetary policy is exogenous with the growth rate of money that follows a first order autoregressive process. In country 1, instead, the monetary authority chooses the growth rate of money optimally, in the sense of maximizing the welfare of the domestic households. The monetary authority cannot credibly commit to future policies. Therefore, the optimal policy is time-consistent.

In the class of time-consistent monetary policies that can be conducted by country 1, we limit the analysis to Markov policies, that is, policies that depend only on the current (physical) states of the economy. Despite we restrict the analysis to this subclass of policies, the analytical characterization of an equilibrium is not available and we solve the model numerically.

4 Equilibrium conditions

Before describing the optimization problems solved by the agents of the two economies, it would be useful to define the equilibrium conditions that need to be satisfied in four markets: the goods market, the loans market, the money market and exchange rate market. The equilibrium conditions in the goods and loan markets in country 1 are:[1]

$$Y_1 = C_1 + \tau^D(D_{11}; D'_{11}) + \tau^F(D_{21}; D'_{21})\mu + X_{11} + X_{21}\mu \qquad (6)$$

[1] We will use capital letters to denote aggregate variables and prices, and lowercase letters to denote individual variables.

$$P_1(X_{11} + e \cdot X_{12}) = D'_{11} + D'_{21}\mu \tag{7}$$

The equilibrium condition in the money market is derived from the household's cash-in-advance constraint (assuming that it is binding) given by:

$$M_1 + T_1 - D'_{11} - D'_{21}\mu = P_1(C_1 + \tau^D(D_{11}; D'_{11}) + \tau^F(D_{12}; D'_{12})e)$$

The left-hand-side is the cash retained for transaction by the household and the right-hand-side are the household's transactions. Using this equation together with equations (6) and (7) we have:

$$M_1 + T_1 = P_1[Y_1 + (\tau_{12} + x_{12})e - (\tau_{21} + x_{21})\mu] \tag{8}$$

This equation expresses the equality between the volume of transactions and the total quantity of liquid funds denominated in the currency of country 1.

Similar equilibrium conditions as expressed in equations (6)-(8) hold in country 2.

Finally, the equilibrium condition in the exchange rate market is:

$$\begin{aligned} P_1 \cdot e \cdot (X_{12} + \tau^F(D_{12}; D'_{12})) + e \cdot (D'_{12} - M_{12}) = \\ P_1 \cdot (X_{21} + \tau^F(D_{21}; D'_{21}))\mu + (D'_{21} - M_{21})\mu \end{aligned} \tag{9}$$

The exchange rate market takes place at the beginning of the period. The demand for foreign currency (currency of country 2) derives from the purchase of the foreign input, the payment of the cost to adjust foreign deposits, and the change in the stock of deposits denominated in foreign currency. For households in country 1, the initial stock of deposits denominated in foreign currency is $M_{12} = (1 + R_{2;-1})D_{12}$, where D_{12} is the previous stock of deposits and $R_{2;-1}$ is the interest rate paid on these deposits. The supply of foreign currency derives from the purchase of the input in country 1 from firms in country 2, the adjustment cost paid by foreign investors, and the net change in the stock of deposits that foreign investors have in country 1.

5 Optimal and time-consistent monetary policy

After describing the economic environment, the objective of this section is to define the optimal monetary policy conducted in country 1 when the monetary authority chooses g_1 on a period-by-period basis and cannot credibly commit to the choice of future g'_1s. As stated above, we restrict the analysis to policies that are Markov stationary, that is, policy rules that are functions of the current aggregate states of both economies. The current states are denoted by s and they are given by the technology levels in the two countries, A_1 and A_2, the current growth rate of money in country 2, g_2, the stock of (per-capita) domestic and foreign deposits , D_{11}, D_{12}, D_{22} and D_{21}, and the total assets denominated in foreign currency, $M_{12} = D_{12}(1 + R_{2,-1})$ and $M_{21} = D_{21}(1 + R_{1,-1})$. The total assets denominated in foreign currency is important because it affects the supply and demand in the foreign exchange market. Transactions in this market take place at the beginning of the period. In addition to the total assets denominated in foreign currency, we have to keep track separately of the stocks D_{12} and D_{21} because they affect the costs of adjusting the portfolio of foreign assets. This adjustment also takes place at the beginning of each period. A policy rule in country 1 will be denoted by $g_1 = \Psi(s)$.

The procedure we follow to define the time-consistent policy consists of two steps. In the first step we define a recursive equilibrium where the policy maker in country 1 follows an arbitrary policy rule $\Psi(s)$. In the second step we ask what the optimal growth rate of money g_1 would be today, if the policy maker anticipates that from tomorrow on it will follow the policy rule $\Psi(s)$. This allows us to derive the optimal g_1 as a function of the current states and the policy rule that will be followed from tomorrow on. The optimal current policy rule, given Ψ followed from tomorrow on, will be denoted by $g_1 = \psi(\Psi; s)$. If the current policy rule ψ is equal to the policy rule that will be followed starting from tomorrow, that is, $\psi(\Psi; s) = \Psi(s)$ for all s, then Ψ is an optimal and time consistent policy rule in country 1. We describe these two steps in detail in the next two subsections.

5.1 The household's problem given the policy function Ψ

In this section we assume that the policy maker commits to some policy rule $g_1 = \Psi(s)$. Then, using a recursive formulation, we will describe the household's problem and define a competitive equilibrium conditional on this policy rule. In order to use a recursive formulation, we normalize all nominal variables by the pre-transfer stock of currency M in which these variables are denominated. The aggregate states of the economy are $s = (A_1; A_2; g_2; D_{11}; D_{12}; M_{12}; D_{22}; D_{21}; M_{21})$. The individual states for households in country 1 are $\hat{s}_1 = (d_{11}; m_{11}; d_{12}; m_{12})$, where m_{11} are the assets denominated in domestic currency and m_{12} are the assets denominated in foreign currency. The problem solved by the household in country 1 is:

$$\Omega_1(\Psi; s; \hat{s}_1) = \max_{d'_{11}; d'_{12}} \left\{ u(c_1) + \beta E\, \Omega_1(\Psi; s'; \hat{s}'_1) \right\} \tag{10}$$

subject to

$$c_1 = \frac{m_{11} + g_1 - d'_{11}(1 + g_1)}{P_1} + \frac{(m_{12} - d'_{12}(1 + g_2)) \cdot e_1}{P_2} - \tau^D(d_{11}; d'_{11}) - \tau^F(d_{12}; d'_{12}) \cdot e_1 \tag{11}$$

$$m'_{11} = d'_{11}(1 + R_1) + \frac{P_1 \pi_1}{(1 + g_1)} \tag{12}$$

$$m_{12}' = d_{12}'(1 + R_2) \tag{13}$$

$$s' = H(\Psi; s) \tag{14}$$

$$g_1 = \Psi(s) \tag{15}$$

In solving this problem, the household takes as given the policy rule Ψ and the law of motion for the aggregate states H defined in equation (14). To make clear that this problem is conditional on the particular policy rule Ψ, this function has been included as an extra argument in the household's value function and in the aggregate law of motion. A similar problem is solved by households in country 2 who also take as given the law of motion for the aggregate states H and the policy rule in country 1, Ψ. The value function in country 2 is denoted by $\Omega_2(\Psi; s; \hat{s}_2)$.

A solution to this problem is given by the state contingent functions $d_{11}'(\Psi; s; \hat{s}_1)$, $d_{12}'(\Psi; s; \hat{s}_1)$ in country 1 and $d_{22}'(\Psi; s; \hat{s}_2)$, $d_{21}'(\Psi; s; \hat{s}_2)$ in country 2. As for the value function, we make explicit the dependence of these decision rules on the policy function Ψ.

We then have the following definition of equilibrium.

Definition 5.1 (Equilibrium given Ψ) A recursive competitive equilibrium, given the policy rule Ψ, is defined as a set of functions for (i) household decisions $d_{11}(\Psi; s; \hat{s}_1)$, $d_{12}(\Psi; s; \hat{s}_1)$, $d_{22}(\Psi; s; \hat{s}_2)$, $d_{21}(\Psi; s; \hat{s}_2)$, and value functions $\Omega_1(\Psi; s; \hat{s}_1)$, $\Omega_2(\Psi; s; \hat{s}_2)$; (ii) intermediate inputs $x_{11}(\Psi; s)$, $x_{12}(\Psi; s)$, $x_{22}(\Psi; s)$, $x_{21}(\Psi; s)$; (iii) aggregate per-capita deposits $D_{11}'(\Psi; s)$, $D_{12}'(\Psi; s)$ $D_{22}'(\Psi; s)$, $D_{21}'(\Psi; s)$, assets denominated in foreign currency $M_{12}'(\Psi; s)$, $M_{21}'(\Psi; s)$ and loans $L_1(\Psi; s)$, $L_2(\Psi; s)$; (iv) interest rates $R_1(\Psi; s)$, $R_2(\Psi; s)$, nominal prices $P_1(\Psi; s)$, $P_2(\Psi; s)$ and nominal exchange rate e; (v) law of motion $H(\Psi; s)$. Such that: (i) the household's decisions are optimal solutions to the household's problems; (ii) the intermediate inputs maximizes the firms' profits; (iii) the market for loans clears and $R_1(\Psi; s)$, $R_2(\Psi; s)$ are the equilibrium interest rates; (iv) the exchange rate market clear and e is the equilibrium nominal exchange rate; (v) the law of motion $H(\Psi; s)$ for the aggregate states is consistent with the individual decisions of households and firms; (vi) all agents choose the same holdings of deposits and firms shares (symmetry).

Differentiating the household's objective with respect to d_{11}' and d_{12}' we get:

$$u'(c_1) = (1 + R_1) E \left(\frac{\beta P_1 u'(c_1')}{P_1'(1 + g_1)} \right) - P_1 \left[\tau_2^D(d_{11}; d_{11}') u'(c_1) + \beta E \tau_1^D(d_{11}'; d_{11}'') u'(c_1') \right] \tag{16}$$

$$u'(c_1) = (1+R_2)E\left(\frac{\beta e' P_1 u'(c_1')}{e P_1'(1+g_1)}\right) - P_1\left[\tau_2^F(d_{12}; d_{12}')e u'(c_1) + \beta E \tau_1^F(d_{12}'; d_{12}'')e' u'(c_1')\right] \quad (17)$$

In country 2, the first order conditions with respect to d_{22}' and d_{21}' are:

$$u'(c_2) = (1+R_2)E\left(\frac{\beta P_2 u'(c_2')}{P_2'(1+g_2)}\right) - P_2\left[\tau_2^D(d_{22}; d_{22}')u'(c_2) + \beta E \tau_1^D(d_{22}'; d_{22}'')u'(c_2')\right] \quad (18)$$

$$u'(c_2) = (1+R_1)E\left(\frac{\beta e P_2 u'(c_2')}{e' P_2'(1+g_2)}\right) - P_2\left[\tau_2^F(d_{21}; d_{21}')u'(c_2)/e + \beta E \tau_1^F(d_{21}'; d_{21}'')u'(c_2')/e'\right] \quad (19)$$

These equations are complicated by the presence of the adjustment cost. Without this cost the equation would reduce to standard Euler equations in dynamic models with money, for domestic and foreign investments.

5.2 One-shot optimal policy and the fixed point of the policy problem

In the previous section we derived the decision rules for the households $d_{11}(\psi; s; \hat{s}_1)$, $d_{12}(\psi; s; \hat{s}_1)$, $d_{22}(\psi; s; \hat{s}_2)$, $d_{21}(\psi; s; \hat{s}_2)$ and the value functions $\Omega_1(\psi; s; \hat{s}_1)$, $\Omega_2(\psi; s; \hat{s}_2)$, for a particular policy rule ψ used in country 1. We now ask what the optimal growth rate of money is today in country 1, if the policy maker anticipates that from tomorrow on it will follow the policy ψ.

The objective of the policy maker in country 1 is the maximization of the welfare of the households in country 1. Consider the following optimization problem of households in country 1:

$$V_1(\psi; s; \hat{s}_1; g_1) = \max_{d_{11}', d_{12}', d_{22}', d_{21}'} \left\{ u(c_1) + \beta E\, \Omega_1(\psi; s'; \hat{s}_1') \right\} \quad (20)$$

subject to

$$c_1 = \frac{m_{11} + g_1 - d_{11}'(1+g_1)}{P_1} + \frac{(m_{12} - d_{12}'(1+g_2)) \cdot e}{P_2} - \tau^D(d_{11}; d_{11}') - \tau^F(d_{12}; d_{12}') \cdot e \quad (21)$$

$$m_{11}' = d_{11}'(1+R_1) + \frac{P_1 \pi_1}{(1+g_1)} \quad (22)$$

$$m_{12}' = d_{12}'(1+R_2) \quad (23)$$

$$s' = H(\psi; s; g_1) \quad (24)$$

where the function $\Omega_1(\Psi, s', \hat{s}'_1)$ is the next period value function conditional on the policy rule Ψ as defined in the previous section. The new function $V_1(\Psi, s, \hat{s}_1, g_1)$ is the value function for the representative household in country 1 when the growth rate of money is g_1 and future policies are determined according to the policy rule Ψ. A similar problem is solved by households in country 2.

After solving for this problem in both countries and imposing the aggregate consistency condition $\hat{s}_1 = s$,[2] we are able to derive the function $V_1(\Psi, s, s_1, g_1)$. This is the welfare level reached by the representative household in country 1, when the current growth rate of money in country 1 is g_1 and the future growth rates will be determined according to the rule Ψ. Because the objective of the policy maker is to choose g_1 to maximize the welfare of the representative household in country 1, the optimal value of g_1 is determined by the solution to the following problem:

$$g^{OPT} = \arg\max_{g_1} V(\Psi, s, s_1, g_1) = \psi(\Psi, s) \tag{25}$$

We then have the following definition of an optimal and time-consistent monetary policy rule.

Definition 5.2 The optimal monetary policy rule $\Psi^{OPT}(s)$ is the fixed point of the mapping $\psi(\Psi, s)$, that is:

$$\Psi^{OPT}(s) = \psi(\Psi^{OPT}, s)$$

The basic idea behind this definition is that, when the agents in both economies (households, firms and the monetary authority) expect that future values of g_1 are determined according to the policy rule Ψ^{OPT}, the optimal value of g_1 today is the one predicted by the same policy rule Ψ^{OPT} that will determine the future values. This property assures that, in the future, the policy maker in country 1 will continue to use the same policy rule, so it is rational to assume that future values of g_1 will be determined according to this rule.

6 Calibration

The period in the model is a quarter and the discount factor β is set to 0.985. The functional form for the utility function is specified as $u(c) = c^{1-\sigma}/(1-\sigma)$ with $\sigma = 2$.

The growth rate of money in the U.S. follows the autoregressive process $\log(1+g'_2) = a + \rho_m \log(1+g_2) + \upsilon$, with $\upsilon \sim N(0, \sigma^2_\upsilon)$. The value assigned to a is such that the average growth rate of money (and inflation) in the U.S. is 0.008 per quarter. The calibration of the other two parameters follows Cooley & Hansen (1989) and set $\rho_m = 0.5$ and $\sigma_\upsilon = 0.0063$.

[2] In writing $\hat{s} = s$ we make an abuse of notation as the vector $\hat{s}$ includes different variables than the vector s. What we mean in writing $\hat{s}_1 = s$ is that $d_{11} = D_{11}$, $m_{11} = M_{11}$, $d_{12} = D_{12}$, $m_{12} = M_{12}$.

The production technologies are characterized by the parameters ν, ϵ, ϕ_1, ϕ_2, and by the level of technology $\bar{A}_1 e^{z_1}$ and $\bar{A}_2 e^{z_2}$, where z_1 and z_2 are the technology shocks in Mexico and U.S. respectively. We assume that they both follow the autoregressive process $z' = \rho_z z + \varepsilon$ with $\rho_z = 0.95$. The innovation variables ε_1 and ε_2 are jointly normal with mean zero. Specifically we assume that $\varepsilon_1 = \rho_\varepsilon \varepsilon_2 + \upsilon$ where $\varepsilon_1 \sim N(0; \sigma_\varepsilon^2)$ and $\upsilon_1 \sim N(0; \sigma_\upsilon^2)$. The parameter ρ_ε determines the correlation structure of the shocks in the two country. In reporting the results we will consider several cases: the case of positive correlation, independence and negative correlation. Once we have fixed ρ_ε, the other two parameters σ_ε and σ_υ are calibrated so that the volatility of aggregate output in the two countries are similar to the data. When we change ρ_ε we also change σ_υ so that the standard deviation of z_1 does not change.

The fraction of liquid funds used by households for transaction purposes is approximately equal to $1 - \nu$. If we take the monetary aggregate $M1$ as the measure of liquid funds used for transaction by households and $M3$ as the measure of their total financial assets, then ν is calibrated by imposing that $1 - \nu$ equals the ratio of these two monetary aggregates. Accordingly, we set $\nu = 0.79$ which is the value found in Mexico.[3] After the normalization $\bar{A}_2 = 1$ and after setting the population in the U.S. to be three times larger than in Mexico ($\mu = 3$) the technology parameters $\bar{A}_1$, ϕ_1, ϕ_2 and ϵ are calibrated by imposing the following steady state conditions: (a) Per-capita GDP in Mexico is 28% the per-capita GDP in the United States; (b) Mexican imports from the U.S. are 14% of GDP; (c) The long-run real exchange rate $\bar{e} = P_2 e / P_1$ is 1; (d) The equilibrium inflation rate in Mexico is 4% per quarter.

The calibration of ϵ, then elasticity of substitution of inputs, requires some discussion.. In Mexico it is assumed that the monetary authority chooses the inflation rate optimally. It turns out that smaller is the value of ϵ (with negative sign for complements), the higher is the optimal inflation rate. This is because when ϵ is small, domestic inputs are not good substitutes for foreign inputs and the country benefits from a stronger currency. To make the appreciation of the currency possible, the interest rate has to be increased and in the long run a higher interest rate requires a higher inflation rate. Therefore, we set ϵ so that the optimal inflation rate, that is the inflation rate such that the monetary authority does not have incentive to deviate from, is equal to the calibration target. We will return to this point later in the description of the results.

The adjustment cost functions are assumed to be quadratic, that is, $\tau^D(d; d') = \phi \cdot ((d' - d - T)/M + \gamma^D)^2$ and $\tau^F(d; d') = \phi \cdot ((d' - d)/M + \gamma^F)^2$, where ϕ, γ^D and γ^F are constant. The values of γ^D and γ^F are such that in the steady state $\tau^D(d; d) = \tau^F(d; d') = 0$. The parameter ϕ determines how effective monetary policy is in determining the

[3] The monetary aggregate structure in the U.S. is not necessarily the same as in Mexico. However, by assuming that the parameter ν is the same for the two countries, we are basically imposing that the U.S. monetary structure is the same. The alternative would be to assume different parameters ν for the two countries. Because the basic results do not change much by do so, for the sake of simplicity we assumed a common parameter ν.

interest rate. The lower the value of Á, the less e®ective are the instruments of monetary policy at in°uencing the real economy. In the limiting case of Á = 0, monetary policy is not determined (policy indeterminacy). For relatively small values of Á the numerical procedure does not converge (due to the low impact of g on the current interest rate) or the approximated dynamic system is unstable. Therefore, we set Á at a value that is su±ciently large so that the numerical procedure converges and the approximated dynamic system is stable. The value chosen is Á = 1000.

The full set of parameter values are reported in table 1.

Table 1: Calibration values for the model parameters.

Intertemporal discount rate	¯	0.985
Relative risk aversion	¾	2.000
Technology parameter	Å$_1$	0.888
Technology parameter	º	0.790
Technology parameter	Á$_1$	0.019
Technology parameter	Á$_2$	0.001
Technology parameter	²	-0.321
Persistence of the technology shock	½$_z$	0.950
Standard deviation of innovation in Mexico	¾$_{z_1}$	0.005
Standard deviation of innovation in U.S.	¾$_{z_2}$	0.003
Persistence of the U.S. monetary shock	½$_m$	0.500
Standard deviation of the U.S. shock	¾$_m$	0.006
Adjustment cost parameter	Á	1000.000

7 Results

In this section we use the calibrated model to address the following question: would the adoption of the U.S. currency increase welfare in Mexico?

To answer this question we perform the following experiment. Assume that we start from the regime in which Mexico uses its own currency and at a particular point in time the Mexican currency is replaced by the U.S. currency. This replacement happens overnight and it is not predicted by agents in both economies. After the replacement, Mexican citizens receive the same transfers of dollars received by U.S. citizens. This implies that the monetary policy implemented in the U.S. is also implemented in Mexico. The growth rate of (now common) money follows the same stochastic process that the growth rate of money followed in the U.S. before the reform.

This unexpected regime shift gives rise, then, to a transition dynamics through which the two economies converge to a new long term equilibrium regime. In computing this transitional path we impose the condition that in the new long-term equilibrium the trade account is balanced on average.[4] By simulating the transitional path many times and averaging, we compute the expected welfare levels obtained by the two countries under monetary independence and dollarization. We then compute the gains of this regime shift by computing the percentage of consumption increase that is necessary to make the expected lifetime utility in the ¯rst regime equal to the expected lifetime utility in the second regime (dollarization). The results are reported in table 2.

Table 2 reports the welfare gains (losses if negative) of switching from the current equilibrium with separate currencies to the equilibrium with a single currency. The total gains (or losses) are the sum of two e®ects associated with the dollarization of the Mexican economy. The ¯rst e®ect derives from the loss of the ability to react optimally to shocks (cyclical independence). In computing these gains we assume that Mexico continues to have the same long-term in°ation rate, but the period-by-period changes in the growth rate of money are dictated by the growth rate of money in the U.S. Speci¯cally, the process for the growth rate of money in Mexico is now $g_1 = \bar{g}_1 - \bar{g}_2 + g_2$ with g_2 that follows the same process as described in the calibration section. The second consequence derives from the reduction in long-term in°ation (long-term independence). In this new regime, $g_1 = g_2$ with g_2 that again follows the same process described previously. In calculating these losses we make three di®erent assumptions about the nature of the asymmetry of real shocks. We assume that are positively correlated with a correlation of .6. This is, in fact, the correlation we calibrate using Solow residuals from both countries over the period from 1980 to 1996. We also assume that they are independent and negatively correlated (as they might be in the case of an oil shock).

The results are striking. As can be seen from the table, the adoption of the U.S. currency implies welfare losses for Mexico. These losses derive from the sum of the losses of losing cyclical independence and long term independence. But, the cost of losing cyclical independence is relatively small and is not sensitive to the asymmetry of the shocks. Most of the of losing monetary independence derives from the fall in the in°ation rate and the associated depreciation of the real exchange rate which is necessary to maintain balance in the external accounts. The U.S. would gain from such a policy because Mexico would be a more inviting market for U.S. exports.

8 Conclusion

In this paper we have analyzed the welfare consequences for Mexico of adopting the U.S. currency. We described a two-country model calibrated using data from Mexico and U.S. We use the model to see the Mexican economy would fare in a transition from a world in which Mexican monetary policy follows an optimal time consistent path to one where it follows U.S. monetary policy. The results of these experiments suggest that Mexico

[4]Without technology and monetary shocks, the equilibrium will converges to a new steady state in which the trade account will be balanced in all periods. With shocks, however, the trade account is balanced only on average.

Table 2: Gains (or losses) of Losing Monetary Independence. (Gains stated as percentage of per-period consumption)

	Gains from loss of cyclical independence	Gains from loss of long-term independence	Total gains
	Positively correlated shocks: $\rho_{\varepsilon} = 0.6$		
Mexican economy	-0.080	-2.652	-2.734
U.S. economy	0.001	0.231	0.231
	Independent shocks: $\rho_{\varepsilon} = 0.0$		
Mexican economy	-0.080	-2.651	-2.733
U.S. economy	0.001	0.231	0.232
	Negatively correlated shocks: $\rho_{\varepsilon} = -0.6$		
Mexican economy	-0.081	-2.652	-2.735
U.S. economy	0.001	0.228	0.229

will not gain from dollarization. The surprising thing about these conclusions is that hinge not on the lost ability to react to real shocks, but on lost ability to set an optimal inflation differential between the two countries.

Real economies are complicated and model economies are greatly simplified. The key results of this paper hinge on two things. The first is that there is a liquidity affect associated with monetary interventions. This is a robust feature of U.S. data and it seems to hold in Mexican data. The second is that Mexican imports of U.S. intermediate goods are complements in production. Both of these key assumptions deserve further investigation. Assuming they are valid, this model economy suggests that only benefits from dollarization of the Mexican economy would flow to the U.S.

(Chapter head:)*

Bibliography

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