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

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Abstract

This paper develops a two-country monetary model calibrated to data from the U.S. and Mexico to address the question of whether dollarization is welfare improving for the U.S. and Mexico. Our findings suggest that dollarization is not necessarily Pareto superior to monetary independence. In particular, we find that dollarization may reduce welfare in Mexico.

1   Introduction

There are two persuasive arguments that are often put forth in support of the idea that many countries would benefit from the adoption of the U.S. dollar as their national currency. One is the standard argument often made in favor of fixed exchange rates, 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 when the exchange rate has to be kept fixed. With "dollarization" this would necessarily be true since monetary policy would largely be tied to U.S. policy. The other argument is that dollarization would solve the credibility and commitment problem for these countries. The idea is that many countries, particularly in Latin America, have long histories of high inflation and a record of breaking promises to pursue monetary policies that lead to low inflation. Taking monetary policy out of the hands of domestic central banks is one way to address this issue. Thus, one of the conjectured benefits of adopting the U.S. dollar hinges on the prospect that this would eliminate an inflationary bias among the participating countries.

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These benefits have to be balanced against the costs associated with the loss of monetary independence that either dollarization or a currency area necessarily implies. 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 will be larger the more asymmetric are the shocks that affect the participating countries.

These considerations suggest two main questions that should be addressed in thinking about the proposal to adopt the U.S. dollar in Mexico. First, is the higher inflation rate in Mexico necessarily the result of the lack of monetary discipline or it can be justified by some principle of optimality in the conduction of monetary policy? Second, is the loss of the ability to react optimally to shocks quantitatively important?

In this paper we address these questions in the context of a simple two-country model where both countries are technologically integrated. The production activity in each country requires two inputs: one is domestically produced and the other is imported. Each country is affected by a productivity shock. Agents own financial assets in the form of bank deposits. These deposits are then used by banks to make loans to firms at the market interest rate, as firms need to finance the purchase of the intermediate inputs. 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 on the real sector of the economy. For monetary policy interventions to have liquidity effects, we have to impose some rigidity in the ability of the households to readjust their portfolio. Following Fuerst (1992) and Christiano & Eichenbaum (1995), we assume that agents have to wait one period before being able to readjust their stock of deposits.

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. There is no commitment technology and the type of policies we analyze are time-consistent.

We contrast the case in which Mexico conducts monetary policy optimally, to the equilibria that would prevail if Mexico adopts the dollar. The adoption of a common currency is usually accompanied by the integration of capital markets. Accordingly, in our framework we assume that the adoption of a common currency also implies perfect mobility of financial investments. In the model we formalize the idea of international mobility of capital by assuming that domestic banks are allowed to make loans to foreign firms.

By comparing the equilibria in these economic environments, we answer the two

questions proposed above. Regarding the first question—namely, whether the current inflation rate in Mexico can be reconciled with the optimality of the Mexican monetary policy—we show that if the production structure in Mexico is sufficiently dependent from intermediate inputs imported from the U.S., then an inflation rate higher than the one in the U.S. is optimal.

The reasoning behind the higher inflation rate of Mexico in the case of monetary independence is quite straightforward. In this environment, because of frictions in the adjustment of household portfolios, the policy maker has the ability to control the domestic interest rate by changing the liquidity in the economy. The interest rate, in turn, affects the real exchange rate. Specifically, a contractionary policy that increases the nominal interest rate, reduces the demand for foreign imports and induces an appreciation of both the nominal and real exchange rate. With the appreciation of the real exchange rate, foreign imports become cheaper (the country needs to give up less domestic production to pay for the foreign imports) and this allows an increase in production and consumption. Agents anticipate this policy behavior and form expectations of higher future nominal interest rates. These expectations will then be fulfilled by future policies and the equilibrium will be characterized by higher interest rates. 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 higher inflation. The key assumption that leads to this result is the assumption that imports are production inputs that are complementary to domestic inputs.

Under these circumstances, dollarization would induce significant welfare looses for Mexico, as it will reduce inflation at a suboptimal level for Mexico. However, if the inflation rate in Mexico is not optimal but is high because of the lack of monetary discipline, then dollarization could be welfare improving. It is still true, however, as long as the optimal inflation rate in Mexico is different from the inflation rate in the U.S., dollarization is not the first best solution for the inflation problems of Mexico.

In addition to studying the implications of a common currency for long-term inflation, we also evaluate the welfare costs of loosing the short-term ability to react optimally to asymmetric internal and external shocks. We compute these costs by comparing the welfare levels reached by Mexico when it conduct monetary policy optimally, with the welfare level when its monetary policy follows the same process as the U.S. monetary policy, but with a higher long-term growth rate of money. The comparison of these two welfare levels provides an evaluation of the costs of loosing cyclical monetary independence.

We find that the costs of losing the ability to react to shocks are much smaller than the potential losses or gains deriving from the reduction of the long term inflation.

2   The environment

Consider a two-country economy. The first country (Mexico) is populated by a continuum of households of total measure 1 and the second country (the U.S.) is populated by a continuum of households of total measure μ. Thus, μ is the population size of country 2 relative to country 1. In both countries households maximize the 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 a continuum of firms. For simplicity we assume that each firm employs one household-worker and has access to the following production technology:

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

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). Technology shocks take the form of stochastic changes in the level of technology A_1. The same production function, with technology level A_2, is used by firms 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 eP_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 currencies). 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:

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

with solution:

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

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

The demands for the domestic and foreign inputs depend positively on the level of technology, 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 for country 1, that is, a fall in $\bar{e}$, has an expansionary effect in this country.

The surplus of a firm in country 1 is denoted by π_1. The surplus is distributed to the households at the end of the period. Given the structure of the model, the form in which the surplus is distributed, whether wages or profits, is irrelevant.

Households hold financial assets in domestic banks. Henceforth we will refer to all financial assets as deposits. The stock of deposits is decided at the end of each period and the households have to wait until the end of the next period before being able to change this stock of deposits. This is the assumption usually made in "Limited Participation" models. The financial intermediary, then, uses these funds to make loans to firms. If we allow for international capital mobility, then domestic banks can make loans to both domestic and foreign firms. Without capital mobility, banks can only lend to domestic firms. In the next few sections we retain the assumption that financial capital cannot move internationally. We will consider capital liberalization in section 7.

In addition to deposits, households also own liquid assets used for transactional purposes as they face a cash-in-advance constraint. In country 1, the cash-in-advance constraint is $P_1 c_1 \leq n_1$, where n_1 denotes the domestic currency retained at the end of the previous period for transaction purposes. The beginning-of-period total financial assets of a household in country 1 are equal to the retained liquidity plus the nominal value of deposits, that is, $n_1 + d_1$.

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 in country 1 is denoted by T_1 and is equal to $g_1 M_1$, where M_1 is the pre-transfer nominal stock of domestic liquid assets (money) expressed in per-capita terms and g_1 is its growth rate. The same notation, with different subscript, is used for country 2. Because transfers are in the form of bank deposits, the monetary authority can increase the liquidity available to domestic intermediaries to make loans by increasing these transfers. Because household can only readjust their portfolios with a time lag, the increase in liquidity induces a fall in the nominal interest rate. This is the liquidity effect of a monetary interventions. Accordingly, the monetary authority controls the interest rate by changing the growth rate of money.

The monetary authority in the first country (Mexico) chooses the current 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, we consider only policies that are time-consistent. In the class of time-consistent policies, we restrict the analysis to Markov policies, that is, policies that depend only on the current (physical) states of the economy. These policies are denoted by $R_1 = \Psi_1(\mathbf{s})$, where $\mathbf{s}$ is the set of aggregate state variables as specified below.

In the second country (the U.S.), monetary policy is assumed to be exogenously given

and is specified as some stochastic process for the growth rate of money. In the event of dollarization, this process for the growth rate of money will be maintained in the whole dollarization area. This implies that Mexico will be subjected to the same monetary policy that is implemented in the United States.

4 Equilibrium conditions

In this section we define the equilibrium conditions that need to be satisfied in all markets of the two economies: the goods markets, the loans markets, the money markets and foreign exchange market. For the moment we assume that there are that capital is not mobile meaning that banks do not make loans to foreign firms. This is a way of capturing the notion that the financial systems of the two countries are not very integrated. We will discuss capital liberalization later.

The equilibrium condition in the goods market in country 1 is:[1]

$$Y_1 = C_1 + X_{11} + X_{21}\mu \tag{5}$$

The gross production (supply) must be equal to the demands of goods for domestic consumption, C_1, and the demand of intermediate inputs from domestic firms, X_{11}, and foreign firms, $X_{21}\mu$.

The equilibrium condition in the loans market, also in country 1, is:

$$P_1(X_{11} + \bar{e} \cdot X_{12}) = D_1 + T_1 \tag{6}$$

The left-hand-side is the demand for loans from domestic firms and the right-hand-side is the supply of loans from domestic banks. Using the cash-in-advance constraint and equations (5)-(6), we get:

$$P_1\Big[Y_1 + \bar{e}X_{12} - X_{21}\mu\Big] = M_1 + T_1 \tag{7}$$

which expresses the equality between the volume of transactions executed with the use of domestically denominated liquid funds, and the total quantity of these funds.

Similar equilibrium conditions as the ones expressed in equations (5)-(7) also hold in country 2. Finally, the equilibrium condition in the exchange rate market is:

$$P_1 \cdot \bar{e} \cdot X_{12} = P_1 \cdot X_{21}\mu \tag{8}$$

The exchange rate market takes place at the beginning of the period after the government transfers. The demand for foreign currency (currency of country 2) derives from the purchase of the foreign input and the supply derives from the purchase of the input in country 1 from firms in country 2.

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[1]We use capital letters to denote aggregate variables and prices, and lowercase letters to denote individual variables. The only exception is the exchange rate that we denote by e to distinguish it from the expectation operator E.

5 Monetary policy equilibrium in a simplified version of the economy

Before characterizing the equilibrium of the economy described above, it is useful to first analyze a simplified version of the model. This simplified version allows us to illustrate the main tensions faced by the policy makers of the two countries in choosing their optimal policies. These same mechanisms are also at work in the more general model. Illustrating them in this simplified version facilitates the understanding of how these forces work in the more general model.

Consider the deterministic version of the model with $A_1 = \bar{A}_1$ and $A_2 = \bar{A}_2$, where $\bar{A}_1$ and $\bar{A}_2$ are constant. Furthermore, to simplify the analysis, assume that there is only one period. Therefore, the model is static and we do not have to deal with the issue of time-consistency.

We keep the assumption that agents (households and banks) are not allowed to invest in foreign countries. This can be considered the limiting case in which capital movements are allowed but there are adjustment costs for transferring funds internationally. The absence of financial flows from one country to the other implies that the trade account must be balanced in each period and the country's consumption is always equal to net production. To simplify the analysis, in this section we change the target of monetary policy. Rather than assuming that the monetary policy in the two countries control the growth rate of money, we assume that they control the nominal interest rate. However, while in country 1 (Mexico) the nominal interest rate maximizes the country's welfare, in the second country (the U.S.) the process for the nominal interest rate is exogenous. In this deterministic version of the model R_2 is just a constant. This change in the target of the monetary authority does not change the qualitative feature of the model.

The equilibrium can then be described by the following three equations:

$$C_1 = \left(\frac{\nu \bar{A}_1}{1+R_1}\right)^{\frac{1}{1-\nu}} \left(\frac{1-\nu+R_1}{\nu}\right) \left[1 + \left(\frac{\phi_1}{\bar{e}}\right)^{\frac{\epsilon}{1-\epsilon}}\right]^{\frac{\nu(1-\epsilon)}{\epsilon(1-\nu)}} \tag{9}$$

$$C_2 = \left(\frac{\nu \bar{A}_2}{1+R_2}\right)^{\frac{1}{1-\nu}} \left(\frac{1-\nu+R_2}{\nu}\right) \left[1 + (\phi_2 \bar{e})^{\frac{\epsilon}{1-\epsilon}}\right]^{\frac{\nu(1-\epsilon)}{\epsilon(1-\nu)}} \tag{10}$$

$$\left[\frac{\bar{A}_1(1+R_2)}{\bar{A}_2(1+R_1)}\right]^{\frac{1}{1-\nu}} \left(\frac{\phi_1}{\phi_2}\right)^{\frac{\epsilon}{1-\epsilon}} = \bar{e}^{\frac{1+\epsilon}{1-\epsilon}} \left[\frac{1+(\phi_2 \bar{e})^{\frac{\epsilon}{1-\epsilon}}}{1+\left(\frac{\phi_1}{\bar{e}}\right)^{\frac{\epsilon}{1-\epsilon}}}\right]^{\frac{\nu-\epsilon}{\epsilon(1-\nu)}} \mu \tag{11}$$

Equation (9) defines the net production and consumption in country 1. Equation (10) defines the net production and consumption in country 2. Equation (11) defines the equilibrium in the exchange rate market (the value of imports must be equal to the value of exports, once evaluated at the same currency). These three equations, derived in the appendix, are functions of only three variables: R_1, R_2 and $\bar{e}$. All the other terms are parameters.

To illustrate the working of this model, figure 1 plots the level of consumption for country 1, as a function of its interest rate, R_1, for given values of the interest rate

Figure 1: Consumption of country 1 as a function of the domestic interest rate for a given interest rate in country 2. Parameter values are $\bar{A}_1 = \bar{A}_2 = 1$, $\nu = 0.9$, $\epsilon = -0.3$, $\phi_1^\epsilon = \phi_2^\epsilon = 0.005$, $\mu = 1$.
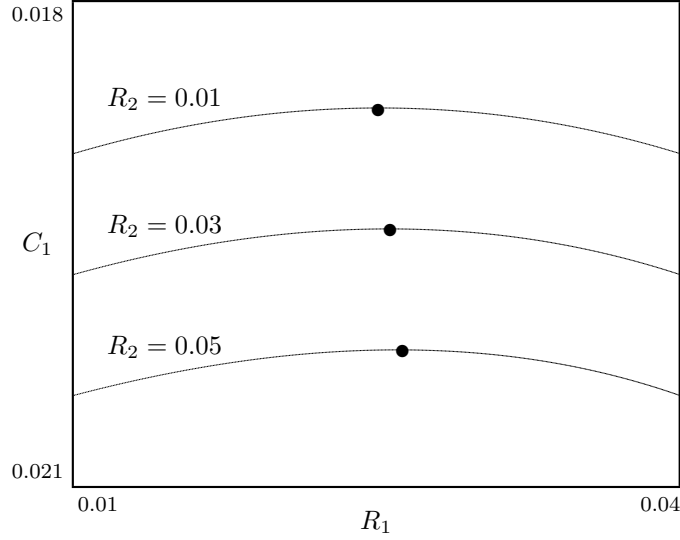
in country 2, that is, R_2.[2] The figure is constructed for the symmetric case in which countries are of equal size and they have the same technology.

According to the figure, consumption in country 1 is initially increasing in R_1 and then decreasing. Therefore, for each R_2, there exists a value of R_1 that maximizes country 1's consumption. The intuition for this result is as follows. Consider country 1. Given the interest rate chosen by country 2, domestic production and consumption depend negatively on the domestic interest rate R_1 and the real exchange rate $\bar{e}$. However, given the external constraint of a balanced trade account, an increase in R_1 also induces a fall in $\bar{e}$ (the country imports less and this induces an appreciation of the exchange rate). Therefore, an increase in R_1 has a direct negative effect and an indirect positive effect on consumption. For low values of R_1 the indirect effect dominates while for high values of R_1 the first effect dominates.

The maximizing value of R_1 constitutes a point in the reaction function of country 1 to the interest rate of country 2. By determining the optimal value of R_1 for each possible value of R_2, we can construct the whole reaction function for country 1.

The parameter ϵ plays a key role in the determination of the equilibrium interest rate in country 1. As we reduce the value of ϵ, that is we increase the degree of complementarity between domestic and foreign imports, the reaction function of country 1 moves

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[2]After fixing R_1 and R_2, the value of consumption C_1 is given by the solutions of the system formed by equations (9) and (11).

up and the reaction function of country 2 moves to the right. This is because when intermediate inputs are not good substitutes, a fall in imports induced by an increase in R_1 generates a large appreciation of the currency which allows the country to import more goods with the same amount of exports, and the monetary authority has a bigger incentive to raise the interest rate. Consequently, for smaller values of ϵ, the equilibrium will be characterized by a higher nominal interest rate in country 1. In a world in which the long term interest rates are determined by a Fisherian rule, the higher interest rates will be associated with higher inflation rates.

Keeping ϵ constant, the larger is the value of imports as a fraction of production for country 1, the higher the interest rate is. This is because production and consumption are more sensitive to the real exchange rate relative to the nominal interest rate.

If we specify the target of the monetary authority in terms of the growth rate of money, we would obtain a similar picture as the one drawn in figure 1. However, to derive this figure we need to introduce more equilibrium equations linking the nominal interest rates to the growth rates of money in both countries. The qualitative features of the model would not change.

6 Optimal and time-consistent monetary policy

The economy analyzed in the previous section is a static version of the more general model described previously. In this section, however, we will show that the static equilibrium described above is also the per-period equilibrium in the infinite horizon model.

The policy maker in country 1 choose g_1 on a period-by-period basis and cannot credibly commit to the choice of future interest rates. In country 2, instead, the growth rate of money, g_2, is exogenously given by some autoregressive process. 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 $\mathbf{s}$ and they are given by the technology levels in the two countries, A_1 and A_2, the growth rate of money in country 2, and the stock of (per-capita) deposits, D_1 and D_2. A policy rule for country 1 will be denoted by $g_1 = \Psi(\mathbf{s})$.

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

6.1 The household's problem given the policy rules Ψ

In this section we assume that the policy maker in country 1 commits to some policy rule $g_1 = \Psi(\mathbf{s})$. Then, using a recursive formulation, we will describe the household's problems in both countries 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 money in which these variables are denominated (either M_1 or M_2). The aggregate states of the economy are $\mathbf{s} = (A_1, A_2, g_1, D_1, D_2)$. The individual states for households in country 1 are $\hat{\mathbf{s}}_1 = (n_1, d_1)$, where n_1 are the liquid assets kept for transactional purposes and d_1 are the bank deposits. The problem solved by the households in country 1 is:

$$\Omega_1(\Psi; \mathbf{s}, \hat{\mathbf{s}}_1) = \max_{d_1'} \left\{ u(c_1) + \beta \, E \, \Omega_1(\Psi; \mathbf{s}', \hat{\mathbf{s}}_1') \right\} \tag{12}$$

subject to

$$c_1 = \frac{n_1}{P_1} \tag{13}$$

$$n_1' = \frac{(d_1 + g_1)(1 + R_1) + P_1 \pi_1}{(1 + g_1)} - d_1' \tag{14}$$

$$\mathbf{s}' = H(\Psi; \mathbf{s}) \tag{15}$$

$$g_1 = \Psi(\mathbf{s}) \tag{16}$$

In solving this problem, the households take as given the policy rule Ψ and the law of motion for the aggregate states H defined in equation (15). To make clear that this problem is conditional on the particular policy rule Ψ, this function have been included as extra argument in the household's value function and in the aggregate law of motion. A similar problem is solved by the households in country 2 who also take as given the law of motion for the aggregate states H and the policy rule Ψ in country 1. The value function in country 2 is denoted by $\Omega_2(\Psi; \mathbf{s}, \hat{\mathbf{s}}_2)$.

A solution to this problem is given by the state contingent functions $d_1'(\Psi; \mathbf{s}, \hat{\mathbf{s}}_1)$ in country 1, and $d_2'(\Psi; \mathbf{s}, \hat{\mathbf{s}}_2)$ in country 2. As for the value functions, we make explicit the dependence of these decision rules on the policy functions Ψ. We then have the following definition of equilibrium.

Definition 6.1 (Equilibrium given Ψ) *A recursive competitive equilibrium, given the policy rules Ψ is defined as a set of functions for (i) household decisions $d_1'(\Psi; \mathbf{s}, \hat{\mathbf{s}}_1)$,*

$d'_2(\Psi; \mathbf{s}, \hat{\mathbf{s}}_2)$, *and value functions* $\Omega_1(\Psi; \mathbf{s}, \hat{\mathbf{s}}_1)$, $\Omega_2(\Psi; \mathbf{s}, \hat{\mathbf{s}}_2)$; *(ii) intermediate production inputs* $X_{11}(\Psi; \mathbf{s})$, $X_{12}(\Psi; \mathbf{s})$, $X_{22}(\Psi; \mathbf{s})$, $X_{21}(\Psi; \mathbf{s})$; *(iii) per-capita aggregate supplies of loans* $L_1(\Psi; \mathbf{s})$, $L_2(\Psi; \mathbf{s})$ *and aggregate demands of deposits* $D'_1(\Psi; \mathbf{s})$, $D'_2(\Psi; \mathbf{s})$; *(iv) money growth* $g_1(\Psi; \mathbf{s})$, $g_2(\Psi; \mathbf{s})$, *nominal prices* $P_1(\Psi; \mathbf{s})$, $P_2(\Psi; \mathbf{s})$ *and nominal exchange rate* $e(\Psi; \mathbf{s})$; *(v) law of motion* $H(\Psi; \mathbf{s})$. *Such that: (i) the households' decisions are optimal solutions to the households' problems; (ii) the intermediate inputs maximizes the firms' profits; (iii) the market for loans clears; (iv) the exchange rate market clear and e is the equilibrium nominal exchange rate; (v) the law of motion* $H(\Psi; \mathbf{s})$ *for the aggregate states is consistent with the individual decisions of households and firms.*

Differentiating the household's objective with respect to d'_1 we get:

$$E\left(\frac{u_c(c'_1)}{P'_1}\right) = \beta E\left(\frac{(1+R'_1)u_c(c''_1)}{P''_1(1+g'_1)}\right) \tag{17}$$

where u_c is the derivative of the utility function (marginal utility of consumption). Similar first order conditions with respect to d'_2 are obtained for country 2, that is:

$$E\left(\frac{u_c(c'_2)}{P'_2}\right) = \beta E\left(\frac{(1+R'_2)u_c(c''_2)}{P''_2(1+g'_2)}\right) \tag{18}$$

These equations are standard Euler equations in dynamic models with money. The presence of the growth rates of money g'_1 and g'_2 derives from normalizing the nominal variables by the total stock of money in which they are denominated.

6.2   One-shot optimal policy and the policy fixed point

In the previous section we derived the value functions $\Omega_1(\Psi; \mathbf{s}, \hat{\mathbf{s}}_1)$, $\Omega_2(\Psi; \mathbf{s}, \hat{\mathbf{s}}_2)$, 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 in this country anticipates that from tomorrow on he will follow the policy Ψ.

Consider first country 1. The objective of the policy maker is the maximization of the welfare of the households in country 1. Therefore, in order to determine the optimal growth rate of money in country 1, the policy maker needs to determine how the households' welfare changes in country 1 as the current growth rate of money changes. In other words, it needs to know the function that links the households' welfare to the current growth rate of money. In order to determine this welfare function, consider the following optimization problem of households in country 1:

$$\mathbf{V}_1(\Psi; \mathbf{s}, \hat{\mathbf{s}}_1, g_1) = \max_{d'_1}\left\{u(c_1) + \beta\, E\,\Omega_1(\Psi; \mathbf{s}', \hat{\mathbf{s}}'_1)\right\} \tag{19}$$

subject to

$$c_1 = \frac{n_1}{P_1} \tag{20}$$

$$n_1' = \frac{(d_1 + g_1)(1 + R_1) + P_1 \pi_1}{(1 + g_1)} - d_1' \tag{21}$$

$$\mathbf{s}' = \tilde{H}(\Psi; \mathbf{s}, g_1) \tag{22}$$

where the function $\Omega_1(\Psi; s', \hat{s}_1')$ is the next period value function conditional on the policy rules Ψ, defined in the previous section. The new function $\mathbf{V}_1(\Psi; \mathbf{s}, \hat{\mathbf{s}}_1, g_1)$ is the value function for the representative household in country 1 when the current growth rate of money in country 1 is g_1, and future rates are determined by the policy rules 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 $\hat{\mathbf{s}}_1 = \mathbf{s}$,[3] we derive the function $\mathbf{V}_1(\Psi; \mathbf{s}, g_1)$. This is the welfare level reached by the representative household in country 1, when the current growth rate of money is g_1 and the future rates will be determined according to the rule Ψ. This is the object we need in order to determine the optimal growth rate of money chosen by the policy maker in country 1. 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:

$$g_1^{OPT} = \arg \max_{g_1} \mathbf{V}_1(\Psi; \mathbf{s}, g_1) = \psi(\Psi; \mathbf{s}) \tag{23}$$

The function $\psi(\Psi; \mathbf{s})$ is the optimal policy rule in the current period when future growth rates of money are determined by the function Ψ.

Using the policy rule ψ we can now define the optimal and time-consistent monetary policy rule.

Definition 6.2 (Time-consistent policy rule) *The optimal and time-consistent policy rule* Ψ^{OPT} *is the fixed point of the mappings* $\psi(\Psi; \mathbf{s})$, *i.e.,*

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

The basic idea behind this definition is that, when the agents in both economies (households, firms and monetary authority in country 1) expect that future values of

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[3]In writing $\hat{\mathbf{s}} = \mathbf{s}$ we make an abuse of notation as the vector $\hat{\mathbf{s}}$ includes different variables than the vector $\mathbf{s}$. What we mean in writing $\hat{\mathbf{s}}_1 = \mathbf{s}$ is that $d_1 = D_1$, $n_1 = 1 - D_1$.

g_1 are determined according to the policy rule Ψ^{OPT}, the optimal values of g_1 today is the one predicted by the same policy rule Ψ^{OPT} that agents assume to 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 used in the current period, so that it is rational to assume that future values of g_1 will be determined according to these rules.

6.3 Properties of the optimal and time-consistent policy in the competitive environment

The absence of capital mobility simplifies the characterization of the optimal and time-consistent policy. The key feature of this economy is that, whatever is done in the current period, this is not going to affect the future. The future will be affected by future states and future policies rules, but these states and rules do not depend on the current equilibrium. This is formally stated in the next proposition.

Proposition 6.1 *The time-consistent policy is the equilibrium policy of the static equilibrium derived in section 5.*

The proposition can be proved following the steps used to define a policy equilibrium as described in the previous sections. Assuming that the future policies are given by the rule in the static equilibrium, we ask whether the policy maker in country 1 has the incentive to deviate from this rule in the current period.

In this economy, households can readjust their portfolio of deposits at the end of each period. In choosing the new stock of deposits, agents only care about future policies. The current policy is irrelevant. Therefore, given the policy rules Ψ assumed for the future, agents will choose their next period stock of deposits. Because the current policy is not going to affect the future states, and therefore policies, the current optimal policy rule is independent of the future rule Ψ. Because agents are rational, they will anticipate that these policy rule will also be followed in the future. Consequently, this rule is time-consistent.

In section 9, we will use this result to analyze the costs and benefits of dollarization for Mexico.

7 Dollarization

The adoption of a common currency, as in the case of dollarization, is only the visible and perhaps the least important aspect of a more complex process of capital market liberalization and integration. The process leading to a common currency is associated with increasing financial integration of the countries adopting the single currency. This integration is the consequence of both legal liberalization and market reactions (the elimination of the exchange rate risk, for example, facilitates foreign financial investments).

To evaluate the costs or gains from dollarization, the process leading to greater capital mobility has to be included in the analysis.

The process leading to greater capital mobility does not happen overnight but takes place through a sequence of intermediate steps. Capturing this sequential process is difficult in the model and to simplify the analysis we make an extreme assumption. We assume that before the adoption of the common currency, there are no financial capital movements. The adoption of the common currency, then, is accompanied by perfect international mobility of financial investments. With free mobility of capital, banks can make loans to both domestic and foreign firms. The consequence of this is that the interest rates in the two countries will be equalized.

With dollarization it is natural to assume that the U.S. retains full discretion in choosing monetary policy. In our framework, this implies that the process of money growth assumed for the U.S. will also be the growth rate of money in Mexico. The assumption that this process does not change after dollarization can be justified by the fact that Mexico is relatively small in economic terms with respect to the U.S. economy.

As pointed out above, a key assumption in the common currency environment is that there is free mobility of capital. The important implication of this assumption is that the interest rates in the two countries are equalized and there is only one interest rate. The equilibrium in the goods markets do not change. For country 1 this condition is still given by equation (5). A similar condition holds for country 2. The equilibrium condition in the loan market becomes:

$$(P_1 X_{11} + P_2 X_{12}) + (P_2 X_{22} + P_1 X_{21})\mu = D_1 + D_2 + T \tag{24}$$

where now P_1 and P_2 are nominal prices for goods produced in country 1 and 2 respectively but denominated in the same currency (currency of country 2). Similarly for deposits and monetary transfers. They are both denominated in the currency of country 2 (dollars).

An important issue is how monetary transfers are distributed between households of country 1 and country 2. To maintain neutrality we assume that transfers are distributed according to a constant fraction to households of country 1 and country 2. In this way we capture the effects of monetary interventions that take place through open market operations rather than monetary transfers.

8 Calibration

The model is calibrated to the data for the United States and Mexico. Country 1 is assumed to be Mexico and country 2 is assumed to be the U.S. The period is assumed to be a quarter and the discount factor β is set to 0.985. The utility function is logarithmic, that is, $u(c) = \log(c)$.

The production technologies are characterized by the parameters ν, ϵ, ϕ_1, ϕ_2 and by the levels 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

country 1 and country 2 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 $\varepsilon_2 \sim N(0, \sigma_\varepsilon^2)$ and $\upsilon \sim N(0, \sigma_\upsilon^2)$. The parameter ρ_ε determines the correlation structure of the shocks in the two countries. 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 outputs in the two countries takes the desired values.[4] 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 $\nu = 0.8$ which is the approximate value found in Mexico.[5]

The parameter ϵ affects the degree of complementarity between domestic and foreign inputs. Assigning a value to this parameter is not easy. Therefore, we will consider different values and will analyze the sensitivity of the results to this parameter. For the baseline model the value of ϵ is chosen so that the quarterly inflation rate in country 1 is 3.5%, which is the approximate current inflation rate in Mexico. 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 $\bar{A}_1$, ϵ, ϕ_1, ϕ_2 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) The inflation rate in Mexico is 3.5%; (c) The value of Mexican imports from the U.S. are 12% of the Mexican GDP; (d) The long-run real exchange rate, $\bar{e} = P_2 e / P_1$, is equal to 1. The full set of parameter values, for the baseline model, are reported in table 1.

Finally, the growth rate of money in the U.S. follows the autoregressive process $\log(1 + g_2') = a + \rho_m \log(1 + g_2) + \varphi$, with $\varphi \sim N(0, \sigma_m^2)$. 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 $\sigma_m = 0.0063$.

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[4]The volatility of output also depends on the process for the monetary shocks in the U.S. economy. However, once the process for the growth rate of money in the U.S. has been parameterized, the volatility of output depends, residually, only on the technology shock.

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

Table 1: Calibration values for the baseline model.

Intertemporal discount rate	β	0.985
Technology parameter	ν	0.800
Technology parameter	ϵ	-0.135
Technology parameter	$\bar{A}_2$	0.980
Technology parameter	ϕ_1^ϵ	0.001
Technology parameter	ϕ_2^ϵ	0.025
Persistence of the technology shock	ρ_z	0.950
Correlation of technology innovations	ρ_ϵ	0.600
Standard deviation of innovation	σ_z	0.005
Persistence of the U.S. monetary shock	ρ_m	0.500
Standard deviation of the U.S. shock	σ_m	0.006
Relative population size of the U.S.	μ	3.000

9   Results

9.1   Optimal policy and equilibrium inflation without aggregate shocks

In this section we examine the properties of the calibrated model without aggregate shocks. This allows us to quantify the welfare consequences of dollarization for Mexico that result from the reduction in long-term inflation.

Table 2 reports the equilibrium inflation and interest rates in Mexico and in the U.S. when Mexico conducts monetary policy optimally and after dollarization. The table also reports the welfare gains from dollarizing. In the deterministic version of the economy the U.S. policy takes the form of a constant growth rate of money, which is equal to the quarterly long-term inflation rate of 0.8%. In the case of dollarization the growth rate of money in Mexico will also be 0.8%.

As can be seen from the table, dollarization is beneficial for the U.S. but not for Mexico. Moreover, the welfare losses for Mexico are quite substantial. In reaching this conclusion, however, we have made an important assumption: the assumption that the policy maker in Mexico is conducting monetary policy optimally, in the sense of choosing the best interest rate for the welfare of the country. Then we have calibrated the economy so that the current inflation rate in Mexico is optimal. Under these conditions it is not surprising that dollarization is not welfare improving for Mexico. One of the motivations underlying the proposal of dollarization is precisely that Mexico does not conduct monetary policy optimally. In this case, dollarization imposes some monetary discipline that could be beneficial for the country.

To allow for this possibility in the simplest possible way, we increase the calibration value of the parameter ϵ but we assume that Mexico is still has the same inflation and interest rates as in the previous version of the economy. With a higher value of ϵ, meaning

Table 2: Steady state equilibrium inflation, interest rate and consumption losses in competitive and cooperative equilibria. Values in percentage terms.

| | $\epsilon = -0.135$ | | $\epsilon = 0.135$ | |
	U.S.	Mexico	U.S.	Mexico
Monetary policy independence				
Inflation	0.80	3.58	0.80	3.52
Interest rate	2.33	5.16	2.33	5.10
Dollarization				
Inflation	0.80	0.80	0.80	0.80
Interest rate	2.33	2.33	2.33	2.33
Consumption gain[1]	0.16	-0.55	0.11	0.41

1.Consumption gains are the percentage increase in consumption when Mexico adopts the U.S.dollar.

imported goods are not as complementary in production, if Mexico were to choose the growth rate of money optimally, it would reduce interest rates and inflation. We justify the higher growth rate of money (and inflation) with a lack of discipline argument that is not explicitly modeled.

In the right section of table 2 we report the welfare computation when $\epsilon = 0.135$. With this parameter value the optimal long-term inflation rate in Mexico would be 1.3%. However, we now assume that Mexico is not conducting monetary policy optimally and the inflation rate is 3.52%. Under these conditions, dollarization is welfare improving for Mexico as well as for the U.S.

In general, our conclusion is that, if the growth rate of money chosen in Mexico is not the optimal one, then the adoption of the dollar could be welfare improving for Mexico. It depends on how different the actual growth rate of money is from the optimal one. However, although dollarization could be welfare improving for Mexico, the exercise emphasizes that dollarization is not the best solution to the problem of monetary discipline. In other words, there is no reasons to believe that the long-term inflation rate in Mexico is exactly equal to the long-term inflation rate in the U.S. In particular, if the country could solve the discipline problem otherwise, then monetary independence would be superior to dollarization.

9.2 The costs of losing discretionary cyclical policy

One objective of this paper is to quantify the welfare costs of losing the ability to use monetary policy to respond to internal and external shocks. We compute the welfare costs of losing monetary discretion by comparing the level of expected welfare reached in the case in which Mexico conducts monetary policy optimally, with the welfare level

reached when the growth rate of money in Mexico follows the same autoregressive process as in the U.S. but with a higher mean (which is equal to the average growth rate of money when Mexico conducts monetary policy optimally). Specifically, 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. This second case is interpreted as the case of loosing cyclical monetary policy independence as a result of dollarization.

Table 3 reports the welfare gains (losses if negative) of loosing cyclical monetary policy independence following dollarization. In calculating these losses we make three different assumptions about the nature of the asymmetry of real shocks. We assume that shocks are positively correlated with a correlation coefficient of .6. This is, in fact, the number we estimate 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).

Table 3: Steady state equilibrium inflation, interest rate and consumption losses in competitive and cooperative equilibria. Values in percentage terms.

	$\rho_\varepsilon = 0.6$		$\rho_\varepsilon = 0.0$		$\rho_\varepsilon = -0.6$	
	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico
Consumption gain[1]	-0.080	0.001	-0.080	0.001	-0.080	0.001

1.Consumption gains are the percentage increase in consumption when Mexico adopts the U.S.dollar.

As can be seen from the table, the adoption of the U.S. currency implies welfare losses for Mexico in terms of loosing the ability to react optimally to shocks. The cost of losing cyclical independence, however, is relatively small and is not sensitive to the asymmetry of the shocks. Consequently, the most important welfare implications of dollarization for Mexico derive from the loss of long-term monetary independence, that is, the ability to choose the optimal inflation rate. Those welfare implications, documented in the previous section, swamp the welfare consequences of losing the ability to conduct discretionary cyclical monetary policy.

10   Conclusion

In this paper we have analyzed the welfare consequences for Mexico from unilaterally adopting the U.S. dollar. We have developed a two-country model in which the U.S. chooses optimal monetary policy independently of what Mexico does but Mexico can influence the terms of trade with its choice of policy. We calibrated the model to data from the U.S. and Mexico. We have distinguished between long-term and cyclical monetary policy independence. The loss of the ability to conduct discretionary cyclical monetary

policy is not quantitatively very important while the loss of long-term independence may have substantial welfare consequences. However, we have shown that dollarization could be welfare improving for Mexico, even though it is not the first-best solution to the monetary policy problems of Mexico.

A   Derivation of equations (9)-(11)

The final goods production in country 1 and country 2, and the equilibrium in exchange rate market are given by:

$$C_1 = A[x_{11}^\epsilon + \phi x_{12}^\epsilon]^{\frac{\nu}{\epsilon}} - x_{11} - \bar{e}x_{12} \tag{25}$$

$$C_1 = A[x_{22}^\epsilon + \phi x_{21}^\epsilon]^{\frac{\nu}{\epsilon}} - x_{22} - x_{21}/\bar{e} \tag{26}$$

$$\bar{e}x_{12} = x_{21}\mu \tag{27}$$

The solutions of the profit maximization problem of firms in country 1 and country 2 (see problem (2)) are:

$$x_{11} = \left(\frac{\nu A}{1+R_1}\right)^{\frac{1}{1-\nu}} \left[1 + \left(\frac{\phi}{\bar{e}}\right)^{\frac{\epsilon}{1-\epsilon}}\right]^{\frac{\nu-\epsilon}{\epsilon(1-\nu)}} \tag{28}$$

$$x_{12} = \left(\frac{\phi^\epsilon}{\bar{e}}\right)^{\frac{1}{1-\epsilon}} x_{11} \tag{29}$$

$$x_{22} = \left(\frac{\nu A}{1+R_2}\right)^{\frac{1}{1-\nu}} \left[1 + (\phi\bar{e})^{\frac{\epsilon}{1-\epsilon}}\right]^{\frac{\nu-\epsilon}{\epsilon(1-\nu)}} \tag{30}$$

$$x_{21} = (\phi^\epsilon\bar{e})^{\frac{1}{1-\epsilon}} x_{22} \tag{31}$$

Using these conditions to eliminated x_{11}, x_{12}, x_{21} and x_{22} in equations (25)-(27) we get equations (9)-(11).

References

Christiano, L. J. & Eichenbaum, M. (1995). Liquidity effects, monetary policy, and the business cycle. *Journal of Money Credit and Banking, 27*(4), 1113–36.

Cooley, T. F. & Hansen, G. D. (1989). The inflation tax in a real business cycle model. *American Economic Review, 79*(3), 733–48.

Fuerst, T. S. (1992). Liquidity, loanable funds, and real activity. *Journal of Monetary Economics, 29*(4), 3–24.