Dollarization and Financial Integration

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November 2003

Abstract

This paper builds a simple theoretical model designed to study dollarization. Each period, a benevolent government decides whether or not to dollarize, how much to borrow or lend on an international bond market, and, if dollarization has not occurred, the devaluation rate. In equilibrium, international borrowing is limited endogenously such that the government always chooses to repay when the penalty for default is permanent future exclusion from financial markets. Dollarization implies the loss of the devaluation rate as a policy instrument, but may still be optimal. The reason is that floating defaulters can use the devaluation rate as a substitute for debt in responding to country-specific shocks while dollarized economies in default find themselves in a more uncomfortable situation. Thus dollarization reduces a government's incentives to default, and thereby increases a country's ability to borrow in equilibrium.

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1 Introduction

The recurrence of currency and financial crises in emerging markets has generated an intense debate on the appropriate exchange rate regime. Dollarization has attracted special attention, in part because of the recent official dollarization of Ecuador and El Salvador.[1]

The most important difference between dollarizing and simply pegging the exchange rate is that dollarizing represents more permanent restrictions on domestic monetary policy. Thus thinking about dollarization leads one to thinking about what a government might have to gain by tying its hands more tightly with regards to monetary policy, which in turn leads to the issue of credibility. In discussing papers in a conference volume on the topic of dollarization, Sargent (2001) writes

> *"In their papers and verbal discussions, proponents of dollarization often appealed to commitment and information problems that somehow render dollarization more credible and more likely to produce good outcomes. Those proponents presented no models of how dollarization was connected with credibility. We need some models."*

In this paper we explore one avenue via which dollarization may increase credibility. In particular, we explore a model in which dollarization enhances a borrowing government's credibility in international financial markets, and thereby increases international financial integration.

The basic idea is as follows. Emerging-markets economies are typically subject to big shocks, large fractions of government revenue are linked to volatile commodity prices, and raising tax rates often increases evasion and substitution towards the informal sector. Thus traditional sources of government revenue are often volatile and difficult to adjust. In this context seigniorage is a valuable fiscal instrument, since extra money can rapidly be printed as required.

At the same time, emerging-markets economies also issue debt to smooth fluctuations and to ease temporary liquidity problems. Dollarization can help strengthen fragile sovereign debt markets by increasing borrowers' incentives to repay loans. The reason is that debt and seigniorage are partial substitutes as revenue sources, so that an economy with an independent monetary policy is prone to default, even if this means future exclusion from credit markets. Dollarization makes the ability to access international debt markets more valuable, reducing the likelihood of default and thereby loosening credit constraints.

In our model a benevolent and rational government decides on the exchange rate regime in the presence of shocks to productivity and to the relative taste for privately versus publicly-

[1] Dollarization in the broad sense of unilaterally adopting a stronger foreign currency such as the U.S. Dollar, Euro, or Yen.

provided consumption goods. If a flexible exchange rate regime is chosen, the government decides on foreign asset holdings and the domestic devaluation rate. The dollarization decision is irreversible, and once dollarized the government's only policy instrument is its international debt position.[2] For simplicity, the government does all the international borrowing and lending in the economy. International debt contracts are not directly enforceable. Rather, foreign creditors set borrowing limits contingent on the exchange rate regime chosen, such that the government always has the incentive to honor its obligations, where the penalty in case of default is permanent financial autarky.

As a first step, we compare a permanently flexible exchange rate regime with a permanently dollarized regime. The parameters defining the shock processes are calibrated so that the flexible exchange rate economy replicates some key features of the Mexican economy. We calibrate to Mexico, since Mexico has frequently been discussed as a candidate for dollarization. We find that large taste shocks are required to account for the fact that government expenditure (and government consumption) is much more volatile than GDP. The model does a good job in terms of replicating some key empirical correlations, such as the acyclicality of government spending, and the negative correlation between government spending and private consumption.

Comparing the permanently flexible regime to the dollarized regime, the dollarized economy exhibits less volatile private consumption and less volatile government spending. In terms of the dynamics of international borrowing, the current account and the net foreign asset position are much more volatile under the dollarized regime, indicating more active use of international borrowing, and the borrowing constraint is looser, as expected. The looser borrowing constraint translates into less frequent debt crises, identified as periods in which the borrowing constraint is binding.

In order to address welfare issues, we then move to consider the version of the model in which the economy starts out under a floating regime, and each period the government decides whether or not to dollarize. We find that dollarization is the optimal regime choice when taste shocks are relatively large to productivity shocks, and when the government's international debt becomes sufficiently large.

1.1 Historical experience

Our model predicts that dollarizing economies should exhibit greater international borrowing ability - which may by manifested either as an increase in international borrowing or as a decline

[2] In reality, it is presumably possible, though costly to de-dollarize a dollarized economy.

in risk-premia - in addition to declines in the level and volatility of inflation. There is not too much direct historical evidence which can be used to test the model, but the experience of the small number of countries that have dollarized appears to be broadly consistent with the predictions of our theory.

Ecuador dollarized in 2000 in the midst of a severe economic crisis with a collapsing banking system, a sliding local currency, and after defaulting on its Brady bonds late in 1999. The regime was implemented in an attempt to reduce inflation, bring stability to the economy, and gain credibility with international investors. Since dollarization, Ecuador's inflation has been significantly reduced to single digits and the country has been able to renegotiate its debts at somewhat lower interest rates.

El Salvador implemented its dollarization plan in 2001 more in an effort to attract foreign investors than to stabilize inflation; the Colon had been pegged to the dollar since 1994. In January 2001, the currency began to be phased out and today the dollar is the only unit of account. The most notable benefit that Salvadoreans have enjoyed post-dollarization is lower interest rates. In fact the day after El Salvador adopted the new currency, the interest rate on consumer loans and mortgages fell from 17 to 11 percent. Consumer credit is growing, and companies and the government have been helped by cheaper international financing.

Panama is the nation that has been dollarized the longest, since 1904. Goldfajn and Olivares (2000) document that Panama has had lower inflation rates than other countries in Latin America. Panama is also strongly integrated in international financial markets, with many foreign banks operating in the country. They report that foreign banks charge lower interest rates on loans than domestic banks.[3]

1.2 Related literature

Proponents of dollarization argue that dollarizing offers other benefits, in addition to greater credibility in international financial markets. One is the greater integration in goods and asset markets that may follow from reducing exchange rate uncertainty and transaction costs. For example, Mendoza (2000) argues that dollarization can deliver substantial welfare gains by eliminating distortionary uncertainty over the duration of stabilization policies, though he does not model the source of this lack of policy credibility explicitly (see also Calvo 1999 and Berg and Borensztein 2000). A second argument in favor of dollarization is that it eliminates the possibility of currency crises. In particular, dollarization solves the 'fear of floating' problem

[3] Other dollarized economies include East Timor, Guatemala, Kosovo and other small countries, and nations such as Bulgaria, Costa Rica and Honduras are also considering this option.

(Calvo 2000) which arises when international liabilities are denominated in dollars and currency devaluations can therefore precipitate debt crises. Third, there is empirical evidence that dollarization brings lower and less volatile inflation to countries adopting a stronger currency (Edwards 2001).

One interpretation of the high and volatile inflation rates in some emerging-markets economies is that these countries face more severe time-consistency problems in setting monetary policy than countries whose currencies are being adopted (see, for example, Cooper and Kempf 2001). Another view is that high inflation rates emerge when countries perceive control of the printing press as an opportunity for beggar-thy-neighbor policy. Thus Cooper and Kempf (2003) build a model in which inflation acts as a tax on foreigners wishing to purchase domestic goods, prompting competitive governments to choose inefficiently-high inflation rates in equilibrium. Similarly, Cooley and Quadrini (2000) argue that Mexico may prefer a higher inflation rate than the U.S. because higher nominal interest rates can have favorable effects on the the terms of trade.

In each of these three cases, dollarization (supposing it can somehow be achieved) might be viewed as increasing monetary policy credibility, in the sense of lowering the equilibrium inflation rate. In this paper we pursue a different explanation for inflation dynamics in emerging-markets economies: episodes of high and volatile inflation simply reflect periods during which less distorting sources of revenue are not available. Thus in our model, policy is always time-consistent and the devaluation rate does not have any beggar-thy-neighbor effects, but dollarizing still reduces the mean and the variance of the inflation rate and the devaluation rate.

Among the costs of dollarization that are often cited are the loss of seigniorage revenues and the inability to respond to external shocks with monetary policy (see, for example, Schmitt-Grohe and Uribe 2001). For developed economies, the advantage of monetary independence is usually expressed in terms of the ability to adjust the short-run real interest rate or the real exchange rate in response to country-specific shocks. For emerging-markets economies, there is often a simpler reason to want to retain the ability to print one's own currency - seigniorage can be an important and flexible source of government revenue. We will document the importance of seigniorage revenue for Mexico and other emerging-markets economies later in the paper. Canzoneri and Rogers (1990) explore the importance of seigniorage in the European Union, and find that the optimal inflation rate is country-specific depends on differences in the efficiency of tax collection systems across countries.

Sims (2002) argues that dollarization is costly because it prevents the economy from issuing (state-contingent) nominal debt, without affecting dollar interest rates. However, governments

in emerging markets are largely unable to issue external debt in their own currency, no matter what exchange rate regime they have, so it is not clear that this constitutes a strong argument against dollarization in practice.

2 Model

We study a very simple small open economy. Output is produced from labor according to a linear technology. Consumption is composed of a mix of privately and publicly-provided goods. A benevolent government seeks to maximize the utility of a representative consumer. The government trades one period bonds in international financial markets at a constant interest rate. However, the government cannot commit to repay international debts; contracts must be self-enforcing. In addition to debt, the inflation rate may be used as an additional policy instrument as long as the value of the currency is allowed to float.

2.1 Households

Households are infinitely-lived and have preferences over privately and publicly provided consumption goods and leisure:

$$E_0 \sum_{t=0}^{\infty} \beta^t u_t(c_t, g_t, 1 - n_t) \tag{1}$$

Period utility takes the following separable form:

$$u_t(c_t, g_t, n_t) = \alpha \ln \left(c_t^{\lambda_t} g_t^{1-\lambda_t} \right) + (1 - \alpha) \ln(1 - n_t), \qquad 0 < \lambda_t < 1, \tag{2}$$

where λ evolves according to a Markov process. In the context of this simple model, we view λ as capturing changes through time in household preferences either for two different types of good (public versus private goods) or changes in the taste for the allocation mechanism (government provision versus market provision). One possible manifestation of these changes taste would be electoral cycles in which populist free-spending governments and more fiscally conservative market-oriented governments take turns in power.[4]

[4] An alternative interpretation of the model is that the household period utility function is time-invariant, and that changes through time in the value for λ really reflect changes in the preferences of the government. This alternative interpretation, as will become clear, has no impact on allocations in the model, though it is, of course, important for welfare issues and the characterization of the optimal exchange rate regime.

In order to simplify the exposition, we shall abstract entirely from nominal variables in the description of the model. Monetary policy will be entirely summarized by the effective tax rate that inflation imposes on consumption. Note that in this one good model with PPP holding, the domestic inflation rate equals the devaluation rate. In the background we have in mind a cash-in-advance economy, in which the government prints new money in the interval of time between when households receive their labor income and when they spend it on consumption goods. The monetary model is described in the appendix.

In the real description of the model, inflation operates as a time-varying tax on consumption. In addition to the consumption tax, households face a constant tax on labor.[5] They make consumption and labor decisions taking as given taxes and the wage rate, subject to the following period-by-period budget constraint

$$(1+\tau_t^c)c_t = (1-\overline{\tau^n})w_t n_t \tag{3}$$

where τ_t^c is the consumption tax rate, and $\overline{\tau^n}$ is the constant labor tax rate.

Combining households' first order conditions and their budget constraint gives the following solution for the optimal labor supply choice:

$$n_t = \frac{\alpha\lambda_t}{\alpha\lambda_t + 1 - \alpha}. \tag{4}$$

Note that this is not the efficient choice for hours, which is independent of λ_t. Households reduce hours in periods when government consumption is relatively highly-valued, since they equate the marginal value of leisure to the marginal value of an additional hour spent producing market consumption. In the efficient allocation, hours are constant through time and equal to α. We get this expression for hours irrespective of the tax rates on labor and consumption, as long as taxes can only be proportional to income. Hours are independent of tax rates because (i) we have log-separable preferences, and (ii) tax revenue is used to finance government spending rather than being rebated lump-sum (as in Cooper and Kempf 2003).

[5] In the next draft of the paper, we plan to make the labor tax a policy choice, though labor taxation will be modelled as a less flexible instrument than inflation taxation. One approach we are considering would be to assume that the labor tax rate must be chosen one period in advance, while the inflation tax can be implemented immediately.

2.2 Firms

Firms produce output according to a linear technology where labor is the only input to production. Output can be freely divided between the privately and the publicly-provided consumption goods. The production technology is subject productivity shocks, which follow a Markov process:

$$Y_t = A_t N_t$$

where A_t is the value for productivity in period t.

The real wage rate in equilibrium is given by the marginal productivity of labor:

$$w_t = A_t$$

2.3 Government

The government is the only actor in the economy with access to a competitive international bond market.[6] In the bond market the government can borrow and lend one-period bonds. The price of these bonds cannot be made contingent on the economy's current net bond position, on net bond purchases, or on the shocks that will hit the economy in the next period. Thus asset markets are far from complete. However, the assumed market structure seems appropriate for emerging-markets economies, for whom international borrowing must typically be repaid at non-contingent dates in non-contingent numbers of U.S. dollars.

In addition to being the single internationally traded asset, debt contracts are also not externally enforceable. We assume that lenders can commit to honor their debt contracts, but the domestic government cannot commit not to default on its debt obligations if it is an international net debtor. If it defaults, creditors are assumed to credibly punish the government by permanently excluding it from the bond market; a defaulting government can neither buy nor sell bonds. Given that bonds are traded at a constant world interest rate, the only way that lenders can assure repayment is by rationing credit.[7] Thus lenders impose endogenous borrowing

[6] In reality, non-government international trade in financial assets is growing, but it is still the case that most external debt in countries where dollarization is considered a possibility represents government borrowing. For example, as of March 2003, Argentina government debt accounts for 67% of the total stock of foreign debt; in Mexico, it accounts for 56% and in Ecuador it accounts for 73%.

[7] One could imagine an alternative market structure in which lenders offer a menu of contracts, each of which specifies a loan amount and an interest rate. Contracts for greater loan amounts would then be associated with higher interest rates to compensate for greater risk of default. In equilibrium the unconditional expected return to the lender would be equalized across contracts. This market structure is adopted in Arellano 2003.

constraints on the government such that no borrowing occurs beyond the point at which the probability of default in the subsequent period is positive. Default incentives, however, depend on the exchange rate regime the government chooses. Thus the maximum amount of borrowing allowed at a point in time is dependent on both current exchange rate policy, and the current state of the economy.

The government finances its expenditures with the consumption (inflation) tax, by taxing labor at a constant rate, and by borrowing from abroad. Each period it decides on the exchange rate regime and on whether to default. Dollarization is assumed to be irreversible; once dollarization is chosen, the inflation rate is taken as given in subsequent periods.

If the dollarization decision has never been taken in the past, the precise timing of decisions is as follows. First, the government observes current period productivity A_t and the current taste shock λ_t and decides whether to dollarize. The dollarization decision and the current period shocks determine the borrowing limit. Given the borrowing limit, the government then decides whether or not to default on its outstanding debt (though this never occurs in equilibrium). Finally, given the dollarization and default decisions, the government chooses values for the available policy instruments. If the government elected to dollarize and default, it gets to set only a permanent labor tax. In this case, dollarization implies inflation equal to the U.S. rate, while default excludes the use of debt as an instrument. If the government elected to dollarize but not to default, it sets the permanent labor tax and chooses net debt purchases. If the government elected to remain floating and to default, it sets the current period inflation (consumption tax) rate. Lastly, if the government elected to remain floating and not to default, it both sets the current period consumption tax and also chooses net debt purchases.

The reason for allowing a dollarizing government to permanently adjust the labor tax rate is that changes in exchange rate regime are often accompanied by fiscal reform. In addition, when inflation stabilizes, real revenues from traditional tax sources typically rise as inflation ceases to erode the real value of revenue that occurs when taxes are collected with a lag. Outside periods when the exchange rate regime changes, we assume that the labor tax rate is constant. This is designed to capture the idea, discussed in the introduction, that income taxes are difficult to adjust, at least over relatively short periods of time.

The timing for an economy that has dollarized is simpler. In this case, the government first decides whether to default (after observing the current period shocks). Then if it defaults, it has no further choices to make; in this case all revenue will come from the previously chosen labor tax rate. If it does not default, the dollarized government chooses net debt purchases.

3 Government's problem when dollarizing

We formulate the government's problem recursively. If the government elects to dollarize it must set $\tau^c = \overline{\tau^c}$, (where $\overline{\tau^c}$ is the U.S. inflation rate) in each future date. In the simulations we will assume $\overline{\tau^c} = 0$. In the first period it elects to dollarize, it chooses a permanent labor tax $\overline{\tau^n}$. In every period it chooses net debt purchases, B'.

The problem of a government that has elected to dollarize in the current period is

$$V_d(B, \lambda, A) = \max_{\overline{\tau^n},\, B'} \{u(c, g, n; \lambda) + \beta E V_d(B', \lambda', A')\} \tag{5}$$

subject to

$$g = \overline{\tau^c} c + \overline{\tau^n} An - B' + (1 + r)B, \tag{6}$$

$$B' \geq \overline{B}^d(\lambda, A), \tag{7}$$

$$c = \frac{(1 - \overline{\tau^n})An}{(1 + \overline{\tau^c})}, \tag{8}$$

and

$$n = \frac{\alpha\lambda}{\alpha\lambda + (1 - \alpha)}. \tag{9}$$

Equation 6 is the government's budget constraint. Equation 7 is the borrowing constraint for the dollarized government. Equations 8 and 9 are the household's budget constraint, and the expression defining the optimal hours choice for the household. The problem for a government that has dollarized in the past is identical, except that $\overline{\tau^n}$ is taken as given rather than being a choice variable. Let $\widehat{V}_d(B, \lambda, A; \overline{\tau^n})$ denote the value function for a government that dollarized in the past and takes as given labor tax rate $\overline{\tau^n}$.

From equation 8, the choice for $\overline{\tau^n}$ effectively determines the average level of future private consumption. Debt policy impacts the time path for government consumption (see 6).

The inter-temporal first order condition for debt is given by:

$$-u_g + \psi + \beta(1 + r)E\left[u'_g\right] = 0 \tag{10}$$

where $u_g = \dfrac{\alpha(1 - \lambda)}{g}$ is the marginal utility of government consumption, and ψ is the multiplier on the borrowing constraint (equation 7).

Equation 10 indicates that under the dollarized regime, debt is used to smooth the marginal utility of public consumption through time. When public consumption is highly valued (low λ),

the government would like to spend more. At the same time, hours worked and tax revenues will be relatively low. Thus debt will be issued these periods.

The endogenous borrowing constraint is such that the government always has incentives for debt repayment. Let $V_d^{aut}(\lambda, A)$ denote the value of autarky when dollarized. Then to ensure that contracts are self-enforcing it must be the case that

$$V_d(B', \lambda', A') \geq V_d^{aut}(\lambda', A') \qquad \forall \lambda', \forall A', \forall B' \geq \overline{B}^d(\lambda, A). \tag{11}$$

International lenders in the bond market can choose what quantity of bonds they are willing to sell to the emerging-economy government, and at what price they want to sell, given that they can earn a safe real return r on the world market. By assumption, the price at which they sell bonds cannot depend on the characteristics of the borrower or the quantity of bonds sold. Given these assumptions and the fact that the market for international loans is competitive, all lenders will sell bonds at the same price $1/(1+r)$, and the borrowing constraint $\overline{B}^d(\lambda, A)$ will be tight enough to guarantee no default for all possible next period states given today's state.

The value of default is strictly increasing in the amount of debt one owes, while the value of autarky is independent of the level of debt (default wipes out all existing debts). Thus the more debt a country has, the more attractive is default. For any combination of shocks in the next period, there is therefore a value for debt such that at that level of debt the government will be indifferent between defaulting and not defaulting. For greater levels of debt default will be strictly preferred, and for smaller levels repayment will be strictly optimal. Let $\overline{B}^d(\lambda, A)$ be the solution to $V_d(\overline{B}^d(\lambda, A), \lambda, A) = V_d^{aut}(\lambda, A)$. The current period borrowing limit will then be the largest $\overline{B}^d(\lambda', A')$ across all (λ', A') combinations that have positive probability:[8]

$$\overline{B}^d(\lambda, A) = \max_{(\lambda', A') \text{ s.t. } pr\left[(\lambda', A')_{|(\lambda, A)}\right] > 0} \overline{B}^d(\lambda', A') \tag{12}$$

4 Government's problem when floating

When the economy is floating, the government can choose to remain floating or to dollarize. The government will choose the regime that gives the highest expected lifetime utility:

[8] To see that this is the appropriate borrowing limit, note that if all other lenders were in total willing to lend an amount strictly less than $\overline{B}^d(\lambda, A)$, then the last lender could make a positive profit on a marginal additional loan by charging a real interest rate greater than r and bearing no default risk. But competition among lenders would then drive the loan rate down to the safe world rate r.

$$V_f(B, \lambda, A) = \max \{V_d(B, \lambda, A),\ V_o(B, \lambda, A)\} \tag{13}$$

where $V_d(B, \lambda, A)$ is the value of dollarizing and is given by 5 and $V_o(B, \lambda, A)$ is the value of deciding to float for at least one more period. When the government chooses to continue floating, it decides on consumption taxes and bond holdings to solve the following problem:

$$V_o(B, \lambda, A) = \max_{\{\tau^c,\ B'\}} \{u(c, g, n; \lambda) + \beta E V_f(B', \lambda', A')\}$$

subject to the following constraints:

$$G = \tau^c c - B' + (1 + r)B \tag{14}$$

$$B' \geq \overline{B}^f(\lambda, A) \tag{15}$$

$$c = \frac{An}{(1 + \tau^c)} \tag{16}$$

$$n = \frac{\alpha\lambda}{\alpha\lambda + (1 - \alpha)} \tag{17}$$

Equation 14 is the government budget constraint under floating exchange rates. Sources of revenue are a period-by-period consumption tax and foreign borrowing. Equation 15 is the borrowing constraint under flexible exchange rates, and it guarantees debt repayment for all shocks and exchange rate regimes in the following period. Equations 16 and 17 reflect aspects of equilibrium household behavior that the government internalizes when choosing consumption taxes and bond holdings. Note that consumption taxes in this model are time-consistent because the household's problem is static.

The endogenous borrowing constraint under floating exchange rates is constructed in a similar way to that in the dollarized economy. Let $\overline{B}^f(\lambda, A)$ be the solution to $V_f(\overline{B}^f(\lambda, A), \lambda, A) = V_f^{aut}(\lambda, A)$, where $V_f^{aut}(\lambda, A)$ denotes the value of autarky when floating given the state (λ, A). The current period borrowing limit will then be the largest $\overline{B}^f(\lambda', A')$ across all (λ', A') combinations that have positive probability:

$$\overline{B}^f(\lambda, A) = \max_{(\lambda', A') \text{ s.t. } pr\left[(\lambda', A')_{|(\lambda, A)}\right] > 0} \overline{B}^f(\lambda', A') \tag{18}$$

The first order condition for the current period consumption tax, τ^c, simplifies to:

$$u_g = u_c \tag{19}$$

or,

$$\lambda_t G_t = (1 - \lambda_t) C_t \tag{20}$$

Thus, if it decides to remain floating, the government uses the consumption tax to obtain an efficient division of output between private and public consumption. Note that this efficient division does not rely on the government being able to use debt.

The inter-temporal first order condition for debt is as in the dollarized economy (see 10). However, since the consumption tax is used to equate the marginal utilities of public and private consumption period by period, smoothing the marginal utility of government consumption through time now also effectively means smoothing the marginal utility of private consumption. In fact, using 14, 16, 17, 20 and 10 the marginal utility of government consumption under floating exchange rates simplifies to

$$u_g = \frac{\alpha}{[An - B' + (1 + r)B]} \tag{21}$$

while the optimal consumption tax rate is given by

$$(1 + \tau^c) = \frac{An}{\lambda [An - B' + (1 + r)B]}. \tag{22}$$

Equation 21 indicates that a floating, credit-worthy government essentially uses debt to smooth output fluctuations. Debt will typically be issued when output is relatively low, which can happen either because of low productivity (low A) or because of low taste for private consumption (low λ).

Equation 22 indicates that if debt is doing its job and smoothing output, then τ^c will typically be higher when the taste for government consumption is high (low λ). Thus inflation and government consumption will tend to commove. Note that for a given level of assets, the more borrowing is done, the larger is the consumption tax. Conversely, if it is difficult to borrow too much (because the borrowing constraint binds) the consumption tax will be higher. In this sense, debt and inflation taxes are partial substitutes in financing government expenditures. Equation 22 also indicates that abstracting from taste shocks, τ^c will be higher the higher is the current level of productivity A.

In both the dollarized and flexible economies, labor supply and output are given by the same expressions. In both economies, the government is seeking to smooth the marginal utility of government consumption through time. When dollarized, tax revenue is simply a fixed fraction of output. When floating, revenue is a changing fraction of output, which varies with the tax rate τ^c. Since τ^c rises when the taste for government consumption is high (see the discussion above) tax revenue tends to rise exactly in those periods when revenue is most needed. Thus if taste shocks are important, we might expect debt policy to be less active in the floating economy. Conversely, if productivity shocks are more important, debt should be used more aggressively in the floating regime. The reason is that when productivity is high in the floating regime, the consumption tax rate rises, so there is a surge in revenue that must be offset by increased savings abroad.

4.1 Government's problem in autarky

If the government defaults it is permanently excluded from credit markets and lives in autarky. But even in autarky, a floating government still gets to choose whether to dollarize or to remain floating. Given that under dollarization tax rates are set permanently, while when floating they are set period by period, the value of default when dollarized is always less than the value of default when floating:[9]

$$V_f^{aut}(\lambda, A) \geq V_d^{aut}(\lambda, A).$$

This implies immediately that simultaneously dollarizing and defaulting is not a good option. Thus, if a floating government defaults, it will choose to remain floating thereafter. In the context of this model, this is a rather obvious point, but it is interesting to note that during the recent crisis in Argentina there were advocates of a default and dollarize strategy. In the model, the only benefit of dollarizing is increased credibility in international financial markets, which is immediately squandered in case of default.

It can be shown that the difference between the value of autarky under a floating regime and under dollarization is independent of productivity shocks. Thus, the main mechanism for dollarization to endogenously provide the government with higher repayment incentives are fluctuating government expenditures needs.

Under autarky, optimal consumption taxes play the same role as in the case where an inter-

[9] In this economy, consumption and labor taxes are essentially isomorphic policy instruments, so what matters is how frequently one can change tax rates, and not whether one has control over the labor tax rate or the consumption tax rate.

temporal smoothing instrument is available; they divide output efficiently between public and private consumption. Consumption taxes under autarky are given by:

$$(1+\tau^c) = \frac{(1-\overline{\tau^n})}{\lambda}$$

The government raises consumption taxes when the value of government consumption is high, and lowers them when the value of private consumption is high. Private and public consumption allocations under autarky are then given by

$$g_f^{aut} = [1-\lambda]\, An \quad \text{and} \quad c_f^{aut} = \lambda An.$$

If the government were to default on its debt obligations when dollarized, period by period public and private consumption are given by

$$c_d^{aut} = \frac{(1-\overline{\tau^n})An}{(1+\overline{\tau^c})} \quad \text{and} \quad g_d^{aut} = \overline{\tau^c}c + \overline{\tau^n}An.$$

4.2 Decision to dollarize

In the floating exchange rate regime, debt and the inflation tax are used to smooth the marginal utility of government consumption, whereas in the dollarized regime only debt serves this function. Thus debt is more valuable to a dollarized government than to a floating regime because it is the sole instrument for smoothing. For this reason, a dollarized government has greater incentives for debt repayment, and in equilibrium it may therefore be possible to sustain more borrowing (support looser borrowing constraints). The irreversible nature of adopting a foreign currency is the key mechanism through which greater credibility can be attained. If dollarization could be undone without experiencing sufficiently large costs, then an indebted country could default and reduce the pain of credit market exclusion by reverting to a flexible exchange rate regime, and restoring the devaluation rate as a shock-absorber.

5 Simulations

We solve three economies: a permanently dollarized economy, a permanently flexible exchange rate economy, and a flexible economy that has the option of dollarization. We compare business cycle statistics and financial integration between the first two economies. Then we characterize the economy with the option of dollarizing, and analyze the conditions under which dollarization

will be chosen as the welfare-maximizing exchange rate regime.

5.1 Parameter values

Given the limited data we have for dollarized economies, we use the permanently flexible exchange rate regime to calibrate the model to mimic empirical regularities in Mexican annual data. The annual interest rate r is set to 4%, and labor's share α is set to 0.7 which are standard values for real business cycle models. This small-open-economy model with borrowing constraints obtains a unique limiting distribution of assets as long as $\beta(1+r) < 1$. We choose the time preference parameter β to match current account volatility in Mexico. The mean value for λ is set to 0.81 to match the mean government expenditure to GDP ratio in Mexico of 19%. Shocks to productivity and to the relative taste for public and private consumption are assumed to be independent of each other and independent over time. The standard deviation of shocks are set jointly to match those of output and government expenditures in Mexico. Table 1 summarizes the parameters values in the model.

Table 1

Parameter Values		Target statistics
Labor's share	$\alpha = 0.3$	$\overline{n} = 0.26$
Interest rate	$r = 0.04$	
Government's share	$\overline{\lambda} = 0.81$	$\frac{\overline{G}}{\overline{Y}} = 18.7\%$
Discount factor	$\beta = 0.949$	$\sigma_{CA} = 0.032$
Std dev of taste shocks	$\sigma_\lambda = 0.0235$	$\sigma_g = 0.108$
Std dev of productivity shocks	$\sigma_A = 0.052$	$\sigma_y = 0.051$

5.2 Permanently floating and permanently dollarized

Table 2 presents business cycle statistics for Mexico. The data are annual series taken from International Financial Statistics for the period 1965-2002, except for current account data that are only available from 1980. Business cycle statistics are computed on logged Hodrick-Prescott filtered data, with the smoothing parameter set to 100.

Consumption and output volatilities are similar in Mexico, with consumption being slightly more volatile. Government expenditures are about twice as volatile as output and account for 18.8% of output. Average inflation in Mexico has been high, with an annual average of about

21.3%, and highly volatile. Seigniorage revenue, defined as the difference in the monetary base, has been on average 2.2% of output, and a significant source of revenue for the government - 11.7% of government spending on average.

In the data, the correlation between consumption and output is positive, and government spending is acyclical. It is interesting to note that government expenditures and consumption are negatively correlated. Inflation rates are negatively correlated with output, and positively correlated with government spending.

Table 2

Business Cycle Statistics for Mexico

	Mean (% Y)	Std Dev	Corr Y	Corr G
Output		0.051		-0.023
Private Consumption	0.689	0.055	0.704	-0.358
Government Expenditures	0.188	0.109	-0.023	
Current Account	-0.027	0.032	-0.464	0.262
Inflation	0.213	0.117	-0.539	0.567

Table 3 shows business cycle statistics for the benchmark model under flexible exchange rates and dollarization. For the flexible economy we use a labor tax rate of zero, and let the government choose the optimal inflation rate to finance government consumption. Business cycle statistics are mean values from 100 simulations of 38 observations each. The simulated data is logged and filtered exactly as with the Mexican data.

The permanently-flexible economy replicates some important features of the Mexican economy. Standard deviations of output, government, and the current account were calibrated jointly by the choices for the standard deviations of shocks and the time preference parameter. The volatility of consumption is close to the output volatility, although slightly lower in the simulated economy. Note that the model can match the simultaneous high volatility of government and low volatility of consumption, even though in the flexible economy the government attempts to smooth the marginal utility of both. The intuition for why this happens is that households work more in states where private consumption is more valued. Thus it is easier for the government to smooth the marginal utility of private consumption through time.

The model can also match the contemporaneous negative correlation between government and private consumption, and the slightly negative correlation between government and output.

In the model, the taste shock makes households value highly private consumption, and simultaneously value public consumption less, which tends to make the correlation negative. But productivity shocks imply a positive correlation, because when output is high, the government optimally wants to increase both public and private consumption.

The model also matches the positive correlation between inflation and government observed in the data. This is because in the flexible economy, the government finances public consumption with the inflation tax revenue and debt.

On the downside, the model with the benchmark calibration does not match the observed negative correlation between inflation and output. The reason is that when productivity is high, the government wants to raise the tax rate in order to be able to repay some debt. However, as we explore below, the correlation between inflation and output crucially depends on the type of shocks the economy faces. When the economy faces only government expenditure shocks, the model generates the negative correlation between inflation and output observed in the data.

The model generates a positive correlation between the current account and output, whereas in the data the correlation in negative. Under floating exchange rates, debt is used to smooth output variations coming from taste and productivity shocks. The government runs down its assets in periods of low output, and engages in precautionary savings in periods of relatively high output. Thus, as in any self-insurance-based model of debt without investment, the current account and output are positively correlated.

Table 3

Business Cycle Statistics for Benchmark Model Economy

	Flexible Economy			Dollarized Economy		
	Std Dev	Corr Y	Corr G	Std Dev	Corr Y	Corr G
Output	0.0519		-0.1768	0.0518	1	-0.1883
Consumption	0.0459	0.7358	-0.6274	0.0518		-0.1883
Government	0.1086	-0.1768		0.0927	-0.1883	
Current Account	0.0323	0.8589	-0.1928	0.0217	0.5936	-0.8975
Inflation	0.0435	0.5010	0.5368	0		
Borrowing Constraint (percentage of output)	-0.0126			-0.0297		

Table 3 also presents statistics for the permanently dollarized economy using the benchmark calibration. We fix the labor tax such that the mean of government consumption is the same

as in the flexible economy case. In several respects, the dollarized economy exhibits a higher degree of international financial integration than the flexible exchange rate economy. The first thing to note is that the dollarized economy can sustain more borrowing in equilibrium: the endogenous borrowing constraint in the dollarized economy is more than twice as large as in the flexible economy. The government of the dollarized economy has less incentives to default because debt is the only policy available for smoothing government fluctuations, and thus the government's credibility in financial markets is increased. Figure 1 presents the distribution of assets in the limiting distribution for the flexible and dollarized economies. Both economies have a distribution of assets that have a probability mass at the constraint. The dollarized economy features a lower probability of being in a financial crises: the probability mass at the respective constraint is 35% in the flexible economy compared to 16% in the dollarized case.

Business cycle statistics in the dollarized economy, are qualitatively similar to those in the flexible economy, although inflation is zero. Consumption volatility is exactly equal to output volatility, because in the dollarized economy with constant taxes there is no way to affect the time path of private consumption. One thing to note is that debt appears to be a good substitute for seigniorage revenue, in the sense that the volatility of government consumption is similar across the floating and dollarized regimes.

In the next set of experiments, we analyze alternative calibrations in which the economy faces only productivity shocks or only taste shocks. The sources of the economy's fluctuations are key determinants of the effects dollarization has on financial integration. The nature of the stochastic structure also sheds light on the source of business cycles. We find evidence for both types of shocks in Mexico.

When the economy's fluctuations come only from taste-type shocks, dollarization has the greatest impact on increasing financial integration: looser debt limits, more volatile current account, and less probability of crises. Table 4 shows business cycle statistics for the economy that faces only taste shocks. Specifically, we use the same parameters as in the benchmark calibration, but kept productivity constant through time.

Table 4

Business Cycle Statistics for Model with only λ Shocks						
	Flexible Economy			Dollarized Economy		
	Std Dev	Corr Y	Corr G	Std Dev	Corr Y	Corr G
Output	0.020		-0.999	0.020		-0.910
Consumption	0.042	0.996	-0.992	0.020	1	-0.910
Government	0.101	-0.999		0.090	-0.910	
Current Account	0.006	0.820	-0.840	0.021	0.939	-0.996
Inflation	0.027	-0.985	0.977	0		
Borrowing Constraint (percent of output)	-0.0005			-0.0263		

An interesting feature of the flexible economy with only taste shocks, is that it delivers the empirically correct negative correlation between inflation and output, and qualitatively the higher standard deviation of inflation relative to output. In this economy, households work less producing lower output, in periods of a high taste for government consumption And at the same time, the government wants to raise revenues, increasing the inflation tax. Figure 2 shows the optimal inflation tax as a function of foreign assets for the two taste shocks. The optimal inflation rate is a decreasing function of the level of foreign assets because the larger the government's savings, the less revenue it needs to raise. Inflation will be the highest, when the economy has low output and is financially constraint, i.e. in crises.

The endogenous borrowing constraint in this experiment increases from about 0 to 2.6% of output when a flexible exchange rate economy is compared with a dollarized economy. The dollarized economy also presents a much more active debt policy, as shown by an increased in the volatility of the current account. Figure 2 also shows net saving as a function of current assets for both shocks. The figure shows how net savings is more sensitive to the current shock in the dollarized economy, producing a more volatile debt policy. The intuition why debt policy is more volatile with dollarization when the model faces only taste shocks is as follows. Debt policy is a substitute for inflation in smoothing the marginal utility of public consumption, but the inflation policy will be most active when the government needs to change the division of output between public and private consumption more frequently. That is, the inflation tax policy is more active when the economy has relatively larger taste shocks. This can be seen by noting that the ratio of the standard deviation of inflation to output increases from .84 in the benchmark model, to 1.36 in the model with only taste shocks. Thus, a dollarized economy,

would be need a more active debt policy, to counteract the loss of the inflation tax instrument.

Another measure of financial integration is the probability that the economy experiences crises. In this model, the probability of crises is reduced by more than in the benchmark model, with a drop in the probability mass at the constraint from 50% to 17%.

In the last experiment, we look at the economy facing only productivity shocks. Table 5 presents business cycle statistics for the flexible and dollarized economies with only productivity shocks. The flexible economy cannot match the high volatility of government consumption observed in the data. Government volatility is much lower and equal to consumption volatility because with only productivity shocks the government uses debt to equate the volatility of private and public consumption through time. Inflation tax does not need to be too volatile in this case because the efficient division of the time varying output is accomplished with a fairly flat tax. Note that the relative volatility of inflation to output is the lowest in this experiment. Inflation, private consumption, output and government consumption all commove in this experiment. In the data however, government consumption is acyclical, and negatively correlated with private consumption. Overall, we find evidence that in Mexico both sources of fluctuations, productivity shocks and government expenditures shocks, are important in order to match the relative volatilities and correlations observed in the data.

For the economy facing only productivity shocks, dollarization does not increase financial integration. The dollarized economy produces a tighter endogenous borrowing constraint than the flexible economy, and a less volatile current account. Both economies are often financial constraint, with an equal probability of being in crises.

Table 5

Business Cycle Statistics for Model with only A Shocks						
	Flexible Economy			Dollarized Economy		
	Std Dev	Corr Y	Corr G	Std Dev	Corr Y	Corr G
Output	0.048		0.828	0.048		0.826
Consumption	0.027	0.828	1.000	0.048	1	0.826
Government	0.027	0.828		0.027	0.826	
Current Account	0.030	0.859	0.429	0.006	0.861	0.430
Inflation	0.036	0.858	0.426	0		
Borrowing Constraint (percent of output)	-0.0103			-0.0019		

Our main findings in this section are that the effect dollarization has on financial integration depends crucially on which type of shocks economies face. If economies fluctuations are mainly due to productivity disturbances, dollarization does not increase financial integration and will never be the welfare improving exchange rate regime. On the other hand, if economies fluctuations are mainly due to shocks affecting government expenditures needs, then dollarization provides a mechanism for the government to gain credibility in financial markets, and thus it increases financial integration.

5.3 Is dollarization welfare improving?

In order to address the welfare implications of dollarization, we now analyze the model where the government has the option of dollarizing. The government will choose dollarization in this framework only if in fact it is welfare improving. In our model, increasing financial integration does not necessarily mean an increase in welfare because there is a real cost of abandoning the inflation tax policy.

We solve the economy for the benchmark calibration, and find that dollarization would never be chosen as the optimal exchange rate regime. With this calibration, the economy will always be better off just letting its currency float to adjust for government fluctuations, than to give up the inflation tax and gain greater financial integration.

We then simulate the economy that has the option of dollarizing for the case of only taste shocks. We find that for this economy, dollarization is welfare improving, and in fact will be chosen as the optimal exchange rate regime, when foreign assets fall below some threshold. Figure 5 shows the dynamics of this economy in the process of dollarizing. Dollarization is chosen in the 11th period after we start the simulation. We can see, that inflation is steadily increasing prior to dollarization, falling to zero when dollarization is chosen. Debt is continually increasing in the simulation and, in the period where dollarization is chosen, the economy can borrow a larger amount of debt. Private consumption falls to a very low level before the economy chooses dollarization. In fact in periods 9th and 10th, the economy is at the constraint, and private consumption remains low. The economy is willing to experience a number of periods of crises, before it finds it optimal to give up the inflation tax and dollarize.

Overall, we find that dollarization can be the optimal exchange rate regime when taste shocks are large relative to productivity shocks, and when the government's international debt becomes sufficiently large. If the government is an international net creditor, on the other hand, the benefits from flexible exchange rates exceed the benefits from greater access to international

credit markets, and thus it is optimal to remain floating.

6 Conclusion

This paper presents a simple model designed to study the interaction between dollarization and credibility in international financial markets. In our model dollarization is costly because seigniorage is lost as a policy instrument. At the same time dollarization is potentially beneficial precisely because eliminating the seigniorage instrument strengthens incentives to repay debt and thereby increases access to international credit. The overall welfare effects depend crucially on which type of shocks economies face. Economies for which shocks to government revenue requirements are important will likely experience the greatest gains from relinquishing control of monetary policy.

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7 Appendix: Nominal variables

Money and prices were absent from the model described above. However, the real economy described above, in which the government's policy instrument is effectively a consumption tax, is equivalent to a cash-in-advance monetary model, which we now describe. For expositional simplicity, we abstract here from other taxes.

At the start of each period, there is a stock M_{t-1} of money in circulation, and all this money is initially held by firms. Individuals decide how much to work, with perfect foresight of how monetary policy will be conducted within the period. When making their labor supply decision they therefore take as given the price P_t at which they will be able to purchase consumption at the end of the period. They also know that the (nominal) wage w_t is such that aggregate payments to labor ($w_t N_t$) exhaust the cash held by firms.

Thus a typical household's budget constraint is given by

$$P_t c_{it} = w_t n_{it}$$

where

$$w_t = \frac{M_{t-1}}{N_t}.$$

Now in between the times when households work and consume, the government prints D_t dollars of new money. So

$$M_t = M_{t-1} + D_t.$$

Assuming inflation is high enough such that it is never optimal for households to carry cash from one period to the next, all money wages will be used to purchase output at the end of the period, and no cash will be carried over into the next period (we can verify ex post that it is never optimal to carry cash forward). Firms carry cash from sales at the end of the current period into the start of the next period.

The quantity equation for the end of the period (given velocity equal to 1) is

$$P_t Y_t = M_t. \tag{23}$$

In equilibrium all households will work the same number of hours and produce the same amount of consumption, so the household's budget constraint (in equilibrium) simplifies to

$$P_t C_t = M_{t-1}$$

Combining these last two equations we get

$$Y_t = C_t + \frac{D_t}{P_t} \tag{24}$$

where $\frac{D_t}{P_t}$ is the real value of seigniorage revenues.

Now return to the household's budget constraint, which, substituting in the expression for the wage and dividing through by the price level, is

$$c_{it} = \frac{M_{t-1}}{P_t N_t} n_{it}.$$

From the quantity equation, $P_t = M_t/Y_t$,so this simplifies to

$$c_{it} = \frac{M_{t-1} Y_t}{M_t N_t} n_{it} = \frac{A_t n_{it}}{\mu_t}$$

where μ_t is the gross growth rate of the money supply. Thus A_t is the real pre-tax wage, and μ_t is effectively a gross tax rate on consumption.

In aggregate, the budget constraint simplifies to

$$C_t = \frac{Y_t}{\mu_t} \tag{25}$$

The government buys output with seigniorage revenue, but it also borrows output from abroad (the bond). The government budget constraint in real terms is

$$G_t + (1+r)B_t = B_{t+1} + \frac{D_t}{P_t}$$

Now combining eqns. 24 and 25 we get

$$Y_t = \frac{Y_t}{\mu_t} + \frac{D_t}{P_t}$$

so the government budget constraint reduces to

$$G_t + (1+r)B_t = B_{t+1} + \frac{(\mu_t - 1)Y_t}{\mu_t}.$$

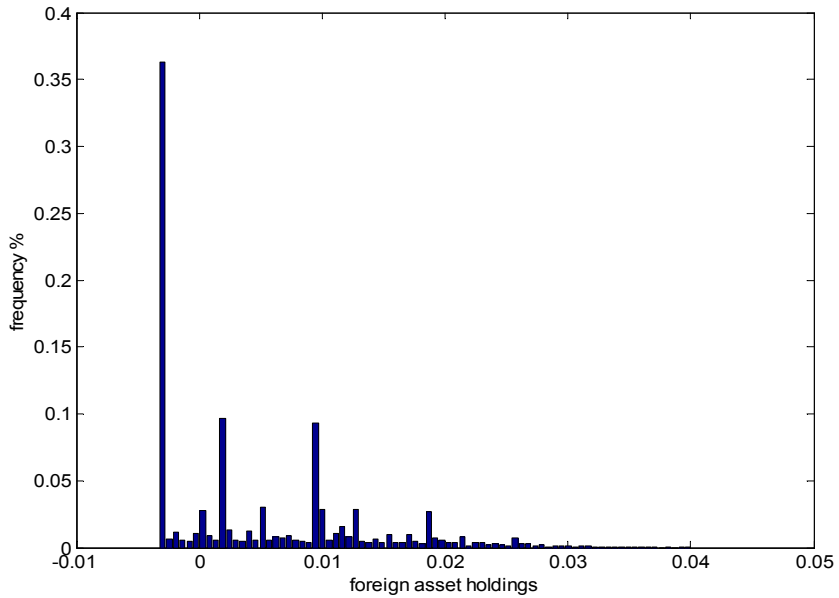
The seigniorage / inflation tax collected by the govt is

$$\frac{(\mu_t - 1)Y_t}{\mu_t} = (\mu_t - 1)C_t.$$

Note that when $1 + \tau_t^c = \mu_t$ the government budget constraint and the household budget constraint in this monetary economy are identical to those in the real economy described in the main text.

Figure 1. Limiting Distribution of Assets

Flexible Economy



Dollarized Economy

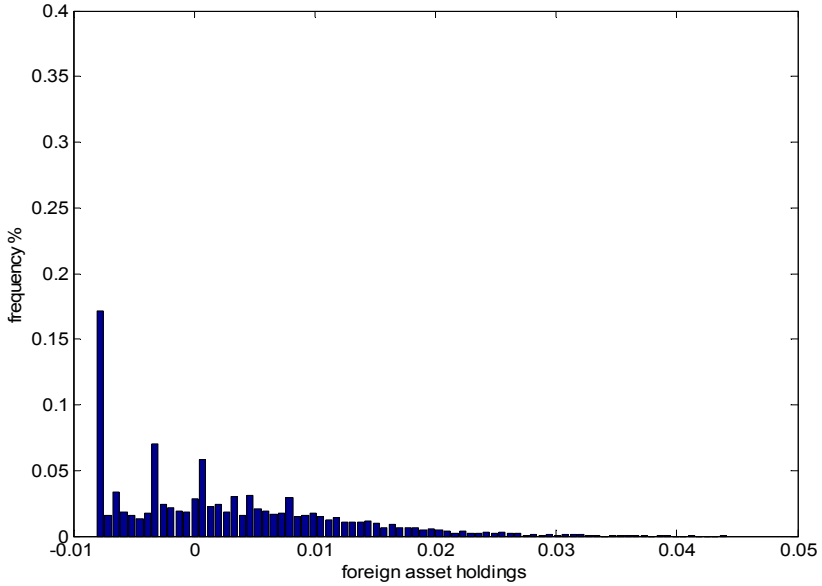
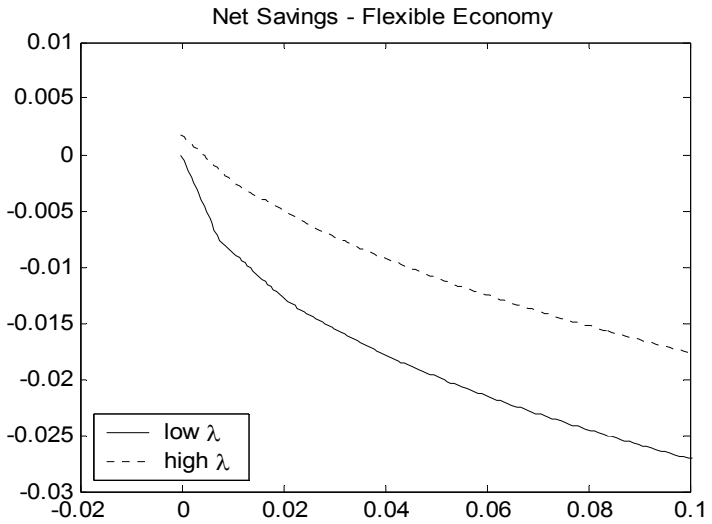
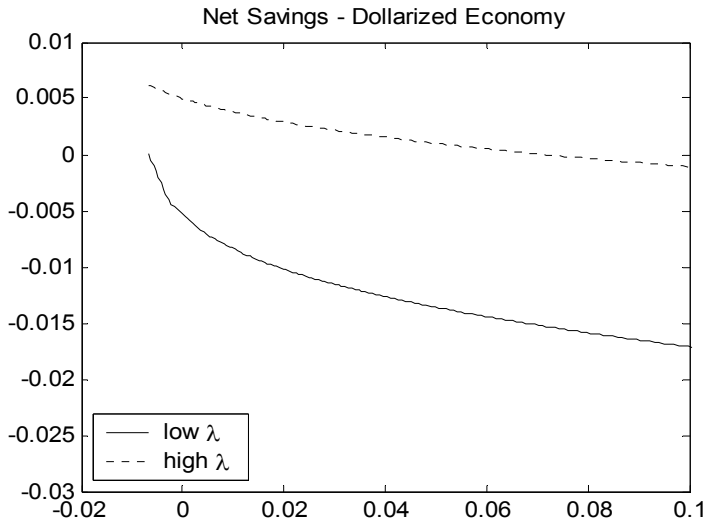


Figure 2. Policy Rules for λ Shocks





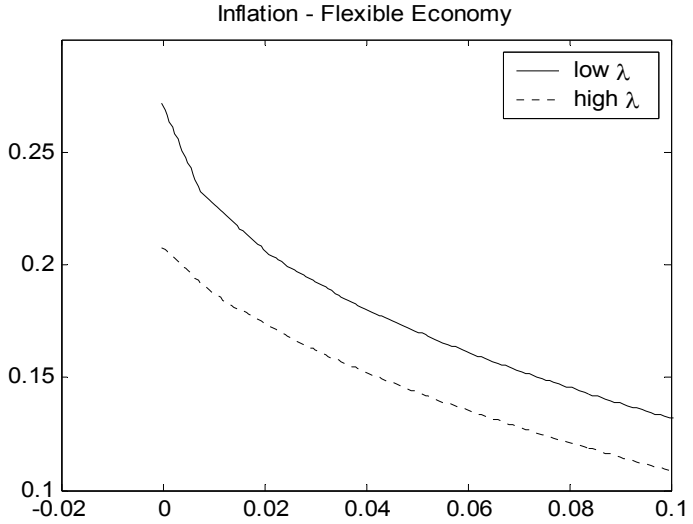
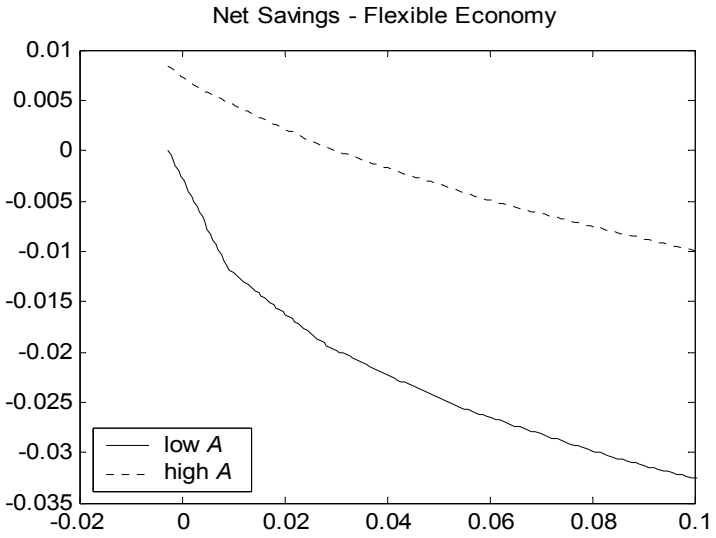
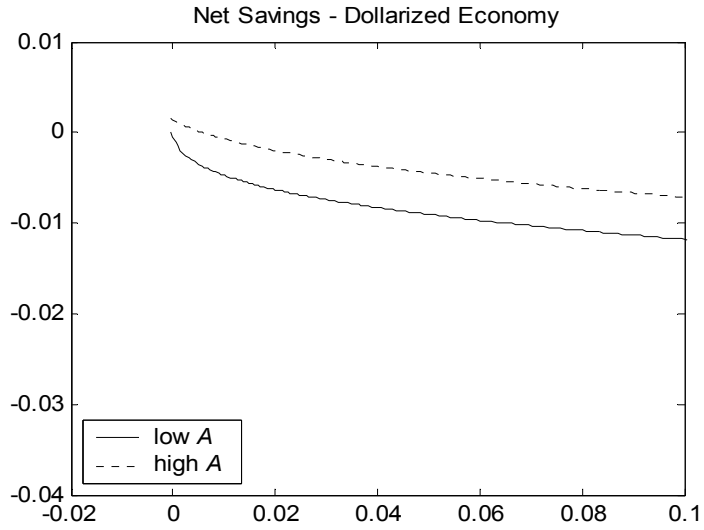


Figure 3. Policy Rules for A Shocks





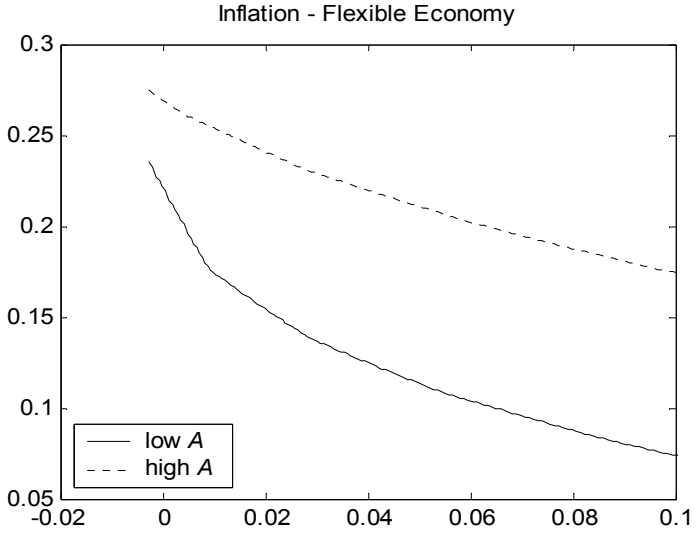


Figure 4. Policy Rules for the Economy with the Option to Dollarized

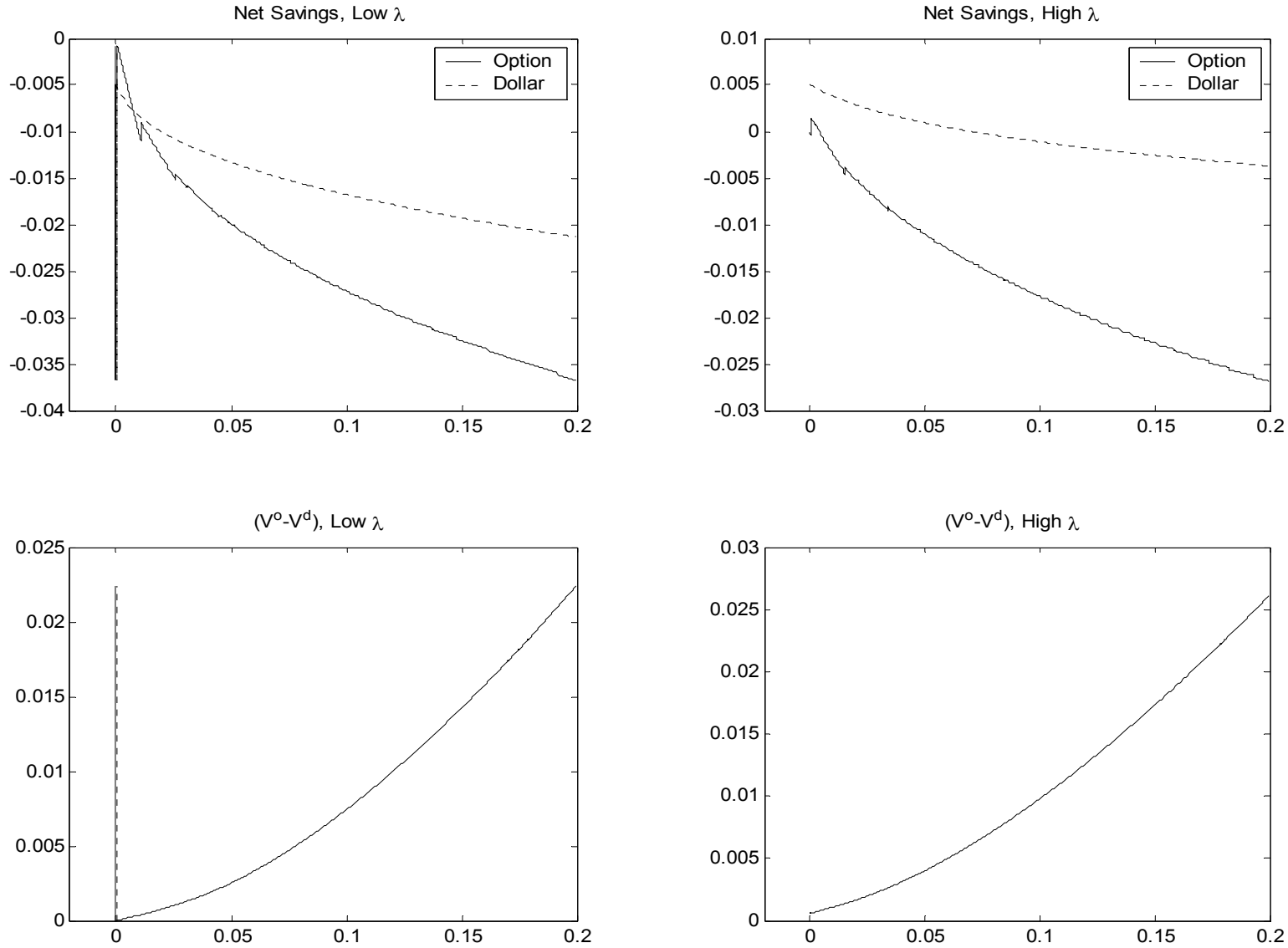


Figure 5. Transition Dynamics from Flexible Economy to Dollarized Economy