Dollarization and Financial Integration*

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Abstract

How does a country's choice of exchange rate regime impact its ability to borrow from abroad? We build a small open economy model in which the government responds to shocks by adjusting domestic monetary policy and foreign borrowing. Sovereign borrowing is subject to endogenous limits, which are just tight enough to ensure repayment when the default punishment is equivalent to permanent exclusion from debt markets.

In this environment, dollarizing implies renouncing monetary policy as an instrument for stabilization. This loss of the monetary instrument can make access to international debt markets more valuable, thereby increasing the amount of borrowing that can be supported in equilibrium. This mechanism linking dollarization to financial integration is consistent with the observed declines in spreads on foreign-currency debt for a set of countries that recently adopted the dollar or the euro.

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1 Introduction

Dollarizing means abandoning domestic monetary policy as an instrument for responding to aggregate shocks. At the same time, proponents of dollarization view improvements in a country's credit worthiness as one of the main benefits from adopting a foreign currency (see, for example, Calvo 2001 and Levy-Yeyati and Sturzenegger 2003b). Motivated by these two observations, we develop a theory that connects dollarization to credibility in international debt markets.[1]

In our model, the extent of sovereign international borrowing is endogenously constrained, because default can only be punished by future exclusion from debt markets. A government that dollarizes relinquishes control over monetary policy, but also faces a different calculus when deciding whether or not to repay debts, precisely because monetary easing is no longer a potential substitute for increased borrowing. If dollarization strengthens repayment incentives, and thus a sovereign's credibility in financial markets, more borrowing can be supported in equilibrium. We highlight the trade-off that arises in the decision to dollarize between the loss of seigniorage as a flexible domestic policy instrument on the one hand, and the potential gain from increased international financial integration on the other.

Retaining the ability to print one's own currency gives governments a flexible way to raise revenue. Emerging markets economies are typically subject to big shocks, and large fractions of government revenue are linked to volatile commodity prices. Moreover, increasing traditional tax rates is difficult, and does not guarantee additional revenue when evasion is widespread and the informal sector is large. In this context seigniorage is a valuable fiscal instrument, since extra money can rapidly be printed as required. Click (1998) documents that seigniorage accounted for a large share of government spending in many Latin American countries in the 1970s and 1980s, and countries with more volatile spending relied more heavily on seigniorage as a fiscal instrument.[2] Calvo and Guidotti (1993) find that inflation taxes tend to be much more volatile than regular taxes in practice. They rationalize this finding by developing a model in which

[1] 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."*

[2] Canzoneri and Rogers (1990) explore the importance of seigniorage in the European Union. They find that the optimal inflation rate is country-specific and depends on the efficiency of the domestic tax collection system.

it is optimal to let changes in the inflation tax do all the work in adjusting to unanticipated fluctuations in spending.[3]

At the same time, emerging markets economies issue debt on international markets to smooth fluctuations and to ease temporary liquidity problems. In our model, dollarization may strengthen fragile sovereign debt markets. The logic is that because dollarizing rules out the use of monetary policy to respond to shocks, it may increase the value to the sovereign of repaying debts and maintaining access to the debt instrument. Suppose the environment is such that a floating government optimally loosens (tightens) monetary policy and debt policy in tandem, by simulatenously raising (lowering) inflation and increasing (reducing) borrowing. Then a dollarized government will want to borrow even more in periods when policy is optimally expansionary to substitute for the fact that it cannot loosen monetary policy. Because borrowing is adjusted more aggressively, debt is a more valuable instrument, and thus dollarization reduces default incentives and loosens borrowing limits. On the other hand, if the environment is such that a floating government optimally repays borrowing in periods when it is loosening monetary policy, then a dollarized government will have less use for debt, indicating tighter borrowing limits. Thus, the relationship between the exchange rate regime and borrowing conditions will depend on the optimal synchronicity of monetary and debt policy, which in turn will depend on the structure of shocks in the economy.

In our model, the government values private and public consumption goods. Because we want to explore the interaction between two dimensions of government policy - domestic money and international debt - we assume the economy is subject to two sources of risk. First, output is stochastic, which introduces a motive for inter-temporal smoothing. Second, the government's relative taste for private versus public consumption fluctuates, which introduces a motive for intra-temporal reallocation between the private and public sectors. Changes in the money growth rate affect the division of output between consumers and the government because of a cash-in-advance friction. The government also trades one period bonds in international financial markets at a constant real interest rate. However, since the government cannot commit to repay

[3] In fact, high volatility of inflation relative to other taxes is a common feature of optimal policy in macro models (see Chari, Christiano and Kehoe, 1995).

international debts, contracts must be self-enforcing as in Zhang (1997). Thus foreign creditors set borrowing limits such that the government always has the incentive to honor its obligations, where the penalty in case of default is permanent financial autarky.

We compare a floating exchange rate regime to a dollarized regime. Under a float, the government chooses debt and sets the money growth rate and thus the inflation rate. Under dollarization, the inflation rate is constant, and the government's only policy instrument is its international debt position. Part of the logic for our story is that it must be costly to switch to a float post default. Thus we focus on full dollarization rather than fixed exchange rate regimes more broadly, where the costs of abandoning a peg are likely smaller.[4]

We explore what determines credit limits, and how they vary across exchange rate regimes. In an extensive sensitivity analysis we find that dollarizing can either increase or reduce the amount of borrowing that can be supported in equilibrium. Relative to a float, borrowing constraints tend to be looser under a dollarized regime (i) the larger are shocks to the relative taste for public versus private consumption, (ii) the less synchronized are periods of high output (and tax revenue) and high demand for government consumption, (iii) the lower is the interest rate, and (iv) the higher is the rate of time preference. We find that dollarizing is welfare-improving in regions of the parameter space where dollarizing supports sufficient additional borrowing to offset the cost associated with losing control of money growth and inflation.

Finally, to get a sense of the quantitative relevance of the trade-off we explore, we consider a calibration to El Salvador (which dollarized in 2001) and to Mexico (which has been discussed as a potential candidate for dollarization). In both cases, we find that large taste shocks are required to account for the high volatility of government spending relative to GDP. The model successfully replicates some key features of the data, such as the co-movement at business cycle frequencies between government consumption on the one hand, and output, private consumption, the inflation rate, and the change in the government's net foreign asset position on the other.

Comparing across the two regimes, we find that in the calibration to El Salvador the dollarized economy exhibits looser borrowing constraints and less frequent debt crises, identified as periods

[4] In an appendix we consider allowing the government to change regimes subject to a cost. We note that dollarized economies that would optimally float post default may still face looser borrowing constraints *ex ante*.

in which the borrowing constraint is binding. The results for the Mexico calibration are quite different: in this case, less borrowing can be supported in the dollarized economy. We interpret the different results for these two countries in terms of the covariance matrix for the underlying shocks.

Relation to existing work: There is a large literature on the pros and cons of dollarization. Perhaps the two most extensively explored arguments in favor of dollarization are that it can increase trade by eliminating currency risk and foreign exchange transaction costs (see, for example, Alesina and Barro, 2002), and can reduce inflation by importing monetary policy credibility (Barro and Gordon, 1983). In addition, there is a widespread belief that dollarization can spur integration into international financial markets. The goal of this paper is to develop a theoretical rationalization for this view.[5] In order to isolate how the choice of exchange rate regime affects access to international credit, our model deliberately abstracts from other potential benefits of dollarization. We now briefly review some of the existing literature, and discuss how our theory connects to previous work.

The evidence on the boost to trade from eliminating currency risk is mostly favorable. Frankel and Rose (2002), and Barro and Tenreyro (2007) find that currency unions boost bilateral trade significantly with other currency union members in a broad sample of countries. However, Lane (2006) notes that to date the Economic and Monetary Union (EMU) in Europe has not increased the importance of intra-euro-zone trade relative to trade outside the euro area. In contrast, there is strong evidence that EMU *has* increased financial integration across the euro area along many dimensions, in particular by reducing bond spreads across member countries.

Dollarization does bring lower and less volatile inflation to countries adopting a stronger currency. A common 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). A competing explanation for why monetary independence leads to higher inflation is that countries perceive control of the printing press as an opportunity for beggar-

[5] Gale and Vives (2002) develop a model in which dollarization strengthens domestic financial markets by reducing moral hazard problems and costly bail-outs in the domestic banking sector.

thy-neighbor policy. 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 (2001) argue that Mexico may prefer a higher inflation rate than the US because higher nominal interest rates can have favorable effects on the terms of trade. In the model of this paper, all prices are flexible and there is no time consistency problem in monetary policy. At the same time, the government takes international prices as given, ruling out strategic international interactions. Thus the key difference between exchange rate regimes in our analysis is the *volatility* of the inflation rate, rather than the average *level* of inflation.

If dollarization is permanent, it eliminates the possibility of currency crises. Mendoza (2001) argues that eliminating distortionary uncertainty over the duration of stabilization policies can deliver substantial welfare gains (see also Calvo 1999 and Berg and Borensztein 2000). Dollarization also solves the "fear of floating" problem (Calvo 2001) which arises when international liabilities are denominated in dollars and currency devaluations therefore precipitate debt crises. In our model economy, episodes of inflation and devaluation do not directly impact the real dollar value of domestic output, and thus do not automatically reduce a country's ability to repay its debts. However, high inflation can signal a lack of willingness to repay debts, given that money growth is used to raise revenue in times of crisis when international credit has been exhausted. Because dollarizing eliminates this last-resort source of revenue, a dollarized government may be more reluctant to exhaust credit lines, making debt crises less frequent.

The paper is organized as follows: Section 2 presents the theoretical model, Section 3 characterizes the equilibrium, Section 4 assesses quantitatively our mechanism, Section 5 describes a range of empirical evidence consistent with our thesis that reducing devaluation risk might also reduce default risk, and Section 6 concludes.

2 The Model

We consider a small open economy populated by a large number of identical consumers, a representative firm, and a government. Consumers work for firms, and each period produce a stochastic quantity of goods that can be used for private or public consumption. Firms sell these goods in exchange for cash. Once the goods market has closed, firms pay their workers. Thus the cash that consumers spend on goods in the current period must be carried over from the previous period.

Exchange rate regimes: We compare two alternative exchange rate regimes. The first is a simple float. Under a float, trade in the cash goods market is conducted using the currency issued by the domestic government, which we label the peso. We allow the government to print new money after observing the firm's output and to spend it immediately to purchase goods that will be provided publicly. The second regime we consider is dollarization. Only foreign currency - dollars - circulate in a dollarized economy. Thus the domestic government has no control over monetary policy and enjoys no seigniorage.

Asset markets: We assume that under both regimes, the government is the only actor in the economy with access to a competitive international bond market. In the bond market the domestic government can sell bonds that take the form of one-period dollar-denominated loans. International lenders decide whether to lend, how much to lend, and at what price to lend. However they cannot make the price of loans contingent on the borrowing government's net foreign asset position, or on the shocks that will hit the economy in the next period. This market structure is appropriate for most emerging markets economies, whose bonds typically specify repayment in foreign currency and on non-contingent terms.[6]

International debt contracts are notoriously difficult to enforce directly. We assume that lenders can commit to honor their contractual obligations, but that the domestic government cannot commit to repay any debts. In the event of default, creditors are assumed to punish the government by permanently excluding it from the bond market: a government that has defaulted in the past can neither issue nor purchase bonds.[7] Bulow and Rogoff (1989) point

[6] The difficulty emerging-markets face in borrowing abroad in their own currencies is referred to as "original sin." See Chapter 1 of Eichengreen and Hausmann (2005) for empirical evidence on the currency denomination of sovereign debt.

[7] Permanent exclusion from trade might sound counter-factually harsh. However, since default is not an equilibrium outcome, what matters for observed allocations is the value of the threatened punishment, and not precisely how it is implemented. Kletzer and Wright (2000) develop a model of sovereign debt in which the

out that if bond purchases are allowed post-default, with no change in the interest rate, then lenders have no way to punish default and no borrowing can be supported *ex ante*. One possible interpretation of our assumption that a defaulting sovereign cannot save is that creditors can seize its dollar-denominated assets post default.[8]

We assume that international lenders can earn a safe real return r on the world market. Competition among lenders combined with the assumption that lending rates must be non-contingent drives all lenders to sell bonds at the same price $1/(1+r)$ and to ensure repayment by rationing credit. Thus lenders impose endogenous borrowing limits on the sovereign such that no borrowing occurs beyond the point at which the probability of subsequent default becomes positive. A key point of the paper is that because default incentives depend on the menu of policy instruments available to the government, the position of these endogenous borrowing constraints will generally differ across the floating and dollarized regimes.

A well-known challenge for the limited enforcement literature is to rationalize high observed debt levels when exclusion from credit markets is the only default punishment. The logic is that the welfare costs associated with aggregate fluctuations tend to be small (Lucas 1987) and thus the incentive to retain access to a smoothing instrument is weak. To generate realistic levels of borrowing, the literature typically assumes that default comes with an additional exogenous penalty in the form of a permanent reduction in output. We do not introduce additional ad hoc punishments because we want to isolate the role of the threat of market exclusion, the cost of which varies endogenously across exchange rate regimes.[9] Arellano (2008) adopts an alternative market structure, in which larger loans are associated with higher interest rates to compensate lenders for the risk of equilibrium default. However, for the calibrations we consider in Section 4, equilibria are observationally equivalent under our market structure and Arellano's, since it is not optimal to borrow beyond the point at which the default premium becomes positive.[10]

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effective punishment for default is equivalent to permanent autarky, but where the punishment is delivered in a way that permits trade to continue, but on worse terms from the borrower's perspective

[8]The literature suggests a variety of ways around the Bulow-Rogoff critique. See, for example, Wright (2002) and Hellwig and Lorenzoni (2009).

[9]Extending the model to introduce such a punishment would not affect the relative ordering of borrowing constraints across exchange rate regimes, as long as the exogenous punishment was equally harsh in both cases.

[10]Quantitative models of debt and default as in Aguiar and Gopinath (2006), Arellano (2008), Chatterjee et. al. (2007), and Yue (2006) generally require either very low discount factors or reduced-form default value

We now lay out the model formally and describe the problems solved by each agent in our economy.

In each period $t = 0, 1, \ldots$ the economy experiences one of finitely-many events $s_t \in S$. An event is a stochastic realization for output, y_t, and a stochastic realization for a preference parameter λ_t. We assume that the pair of shocks $s_t = (y_t, \lambda_t)$ evolves according to a first-order Markov process. We denote by $s^t = (s_0, \ldots s_t) \in S^t$ the history of events up to and including period t. The probability, as of date 0, of a particular history s^t is $\phi(s^t)$.

Output $y(s^t)$ is produced by the representative firm and can be converted into a private consumption good $c(s^t)$ or a public consumption good, $g(s^t)$. Output is produced at the start of the period, and then allocated between consumers and the government in a cash market in the middle of the period. At the end of the period, firms pay their workers (consumers) nominal wages $w(s^t)$.

We assume that the government is benevolent, following the tradition of the literature on optimal policy.[11] Consumers are infinitely-lived, discount at rate β, and derive utility from both private and public consumption goods. Expected lifetime utility is given by

$$\sum_{t=0}^{\infty} \beta^t \sum_{s^t} \phi(s^t) u(c(s^t), g(s^t), \lambda(s^t)) \tag{1}$$

where period utility is

$$u(c(s^t), g(s^t), \lambda(s^t)) = \lambda(s^t) \ln c(s^t) + (1 - \lambda(s^t)) \ln g(s^t) \qquad \text{and } 0 < \lambda(s^t) < 1. \tag{2}$$

In the context of the model, shocks to the taste parameter $\lambda(s^t)$ play two roles. First, a second source of uncertainty introduces a clear role for a second policy instrument, and suggests a downside to renouncing the monetary instrument by dollarizing. Second, when we later calibrate the model to El Salvador and Mexico, we find that demand-side shocks of some sort are required to account for the high volatility of private and public consumption in the data. Variation over time in the taste parameter $\lambda(s^t)$ can be interpreted as capturing changes through time in

functions in order to generate equilibrium default and positive default risk premia.

[11] See, for example, Lucas and Stokey (1983) and Chari and Kehoe (1999).

preferences for public versus private goods, or changes in the taste for the allocation mechanism (government versus market provision).[12]

We assume that cash is the only savings vehicle available to consumers. The representative consumer enters the period with money savings from the previous period $m^s(s^{t-1})$ and wages from the previous period $w(s^{t-1})$. He observes the endowment shock $y(s^t)$, the taste shock $\lambda(s^t)$, and the price level $P(s^t)$. He then decides how much of his money to spend, subject to the cash-in-advance constraint and the budget constraint:

$$P(s^t)c(s^t) \leq m^s(s^{t-1}) + w(s^{t-1}) \equiv m(s^{t-1}) \tag{3}$$

$$m^s(s^t) = m(s^{t-1}) - P(s^t)c(s^t) \tag{4}$$

where $m(s^{t-1})$ denotes total nominal balances carried into period t. Consumers can only save and purchase goods in the currency of circulation: pesos in the floating economy and dollars in the dollarized economy. Note that we do *not* assume at the outset that shocks are small enough to rule out money saving, because the variance of shocks is an important determinant of the position of borrowing constraints. In fact, for realistic amounts of volatility, we will find that money saving typically does occur in equilibrium. We assume throughout that the rest of the world uses only dollars, and that the foreign dollar price level $P^*(s^t)$ is constant and normalized to one.

2.1 Household problem

The household problem is to choose sequences for money savings $m^s(s^t)$ and consumption $c(s^t)$ to maximize expected lifetime utility subject to the cash-in-advance constraint (eq. 3), the budget constraint (eq. 4) and a non-negativity constraint on consumption, $c(s^t) \geq 0$, taking as a given a complete set of date and state contingent endowments $y(s^t)$, taste shocks $\lambda(s^t)$, wages $w(s^t)$,

[12] Relaxing the assumption of benevolence would admit a wider range of interpretations for fluctuations in $\lambda(s^t)$. For example, one could imagine that households assign constant (perhaps zero) weight to government consumption, and that fluctuations in $\lambda(s^t)$ in the policymaker's objective function reflect fluctuations between self-interest and benevolence. Endogenous debt limits and the dynamics of debt depend only on the preferences of the government, irrespective of whether the government's utility function is aligned with that of private households.

prices $P(s^t)$, probabilities $\phi(s^t)$, and initial money holdings m_{-1}.

The representative household's inter-temporal first order condition is

$$\begin{aligned} \phi(s^t)\frac{\lambda(s^t)}{c(s^t)} &\geq \beta \sum_{s_{t+1}} \phi(s^t, s_{t+1}) \frac{\lambda(s^t, s_{t+1}))}{\pi(s^t, s_{t+1})c(s^t, s_{t+1})} \\ &= \text{ if } m^s(s^t) > 0 \end{aligned} \tag{5}$$

where $\pi(s^t, s_{t+1}) = P(s^t, s_{t+1})/P(s^t)$ denotes the gross inflation rate when next period's state is s_{t+1}.

The transversality condition is

$$\lim_{t\to\infty} \beta^t \sum_{s^t} \phi(s^t) \frac{\lambda(s^t)}{c(s^t)} \frac{m^s(s^t)}{P(s^t)} = 0. \tag{6}$$

2.2 Policy when floating

The government in the floating regime decides on a policy $\Lambda = \{g(s^t), B(s^t), M(s^t)\}$ which defines government consumption $g(s^t)$, dollar-denominated assets $B(s^t)$, and the quantity of pesos in circulation $M(s^t)$ for all $t \geq 0$ and for all s^t given some initial assets B_{-1} and nominal balances M_{-1}. We envision policies being chosen at time zero, rather than sequentially. However, we will show that there is no time inconsistency problem in this economy, so the time zero and sequential formulations effectively coincide.

The government is not subject to a cash-in-advance constraint since it can print new money after observing $y(s^t)$ and $\lambda(s^t)$ and use this money immediately to help finance public consumption, $g(s^t)$. Let $M(s^t) = M(s^{t-1}) + N(s^t)$ denote the aggregate stock of money in circulation at the end of period t. Thus the money growth rate $\mu(s^t)$ is equal to

$$\mu(s^t) = \frac{M(s^t)}{M(s^{t-1})} = \frac{M(s^{t-1}) + N(s^t)}{M(s^{t-1})}.$$

In addition to seigniorage and revenue from international borrowing, the government also seizes a constant fraction τ of the endowment directly, with no money changing hands. This can be interpreted as a constant tax rate on private-sector output or, alternatively, as the government producing fraction τ of output. Thus the government nominal budget constraint, prior to default, is given by

$$P(s^t)g(s^t) = \tau P(s^t)y(s^t) + N(s^t) - P(s^t)B(s^t) + (1+r)P(s^t)B(s^{t-1}) \tag{7}$$

where $B(s^t)$ are dollar bonds purchased at s^t. Bond purchases and sales are denominated in pesos by multiplying by the nominal exchange rate, which is equal to $P(s^t)$, the price of goods in pesos relative to the price in dollars, $P^*(s^t) = 1$.

In addition, assets purchased must exceed some state-contingent limit:

$$B(s^t) \geq \underline{B}^f(s^t). \tag{8}$$

The government is allowed to default at any date. If the government chooses to default, then for all future histories the government budget constraint becomes

$$P(s^t)g(s^t) = \tau P(s^t)y(s^t) + N(s^t). \tag{9}$$

Note that after default, the government cannot save abroad, either in dollar-denominated bonds, or dollar cash.

As discussed above, lenders will not lend beyond the point at which the default probability becomes positive. We assume that the constraints $\underline{B}^f(s^t)$ are tight enough to deter the government from ever defaulting in equilibrium, but "not too tight" in the sense of Alvarez and Jermann (2000). In particular, constraints would be too tight if it were possible to loosen the constraint marginally for at least one s^t without this change ever inducing a borrowing-constrained agent to default.

2.3 Policy when dollarized

The policy environment in a dollarized economy differs from the one described above in two respects. First, the money growth rate is not a domestic policy instrument but is chosen by the foreign government. Dollarization implies $P(s^t) = P^*(s^t) = 1$. Given that the domestic government cannot print new money, the term $N(s^t)$ drops out of the pre and post-default government budget constraints (eqs. 7 and 9) which become

$$\begin{aligned} g(s^t) &= \tau y(s^t) - B(s^t) + (1+r)B(s^{t-1}) && (10) \\ g(s^t) &= \tau y(s^t) && (11) \end{aligned}$$

Second, as we have already emphasized, the maximum amount of borrowing allowed at a point in time, $\underline{B}^d(s^t)$, will differ from that under the floating economy $\underline{B}^f(s^t)$.

2.4 Equilibrium relationships

The following relationships apply to both economies.

At the end of the period, firms pay as wages all the cash they hold. Thus

$$w(s^t) = P(s^t)(1-\tau)y(s^t). \tag{12}$$

Since all the money circulating in the economy at the end of the period is held by households,

$$M(s^t) = M(s^{t-1}) + N(s^t) = m(s^t). \tag{13}$$

In the floating regime, $N(s^t)$ denotes the domestic government's newly-printed money, while in the dollarized economy, $N(s^t)$ denotes dollar net purchases of domestically-produced goods by foreigners.[13]

The market clearing condition for the cash goods market is

$$\begin{aligned} P(s^t)(1-\tau)y(s^t) &= M(s^{t-1}) - m^s(s^t) + N(s^t) && (14) \\ &= M(s^t) - m^s(s^t) \end{aligned}$$

[13] Negative $N(s^t)$ can be interpreted as follows. Under a float the domestic government is borrowing goods abroad, selling them on the domestic market, and taking the domestic money it receives in exchange out of circulation. Under dollarization, domestic consumers are buying goods from abroad.

Note that if households do no money saving ($m^s(s^t) = 0$) we get the standard quantity equation with velocity equal to one.

The aggregate resource constraint under flexibility is:

$$c(s^t) + g(s^t) = y(s^t) - B(s^t) + (1+r)B(s^{t-1}) \tag{15}$$

while the corresponding constraint under dollarization is

$$c(s^t) + g(s^t) + N(s^t) = y(s^t) - B(s^t) + (1+r)B(s^{t-1}). \tag{16}$$

These conditions can be interpreted as follows. Under a float, all international borrowing and lending is conducted by the government, and thus the change in the government's bond position is the only item on the capital account. In the dollarized economy, there is an additional private source of capital flows associated with changes in the quantity of dollars circulating domestically, $N(s^t)$.

For each regime, combining the government budget constraint and the aggregate resource constraint (eqs. 7 and 15, or eqs. 10 and 16) gives an alternative expression for private consumption:

$$P(s^t)c(s^t) = (1-\tau)P(s^t)y(s^t) - N(s^t). \tag{17}$$

Let $x(s^t)$ denote the fraction of aggregate cash on hand that agents save at s^t :

$$x(s^t) = \frac{m^s(s^t)}{M(s^{t-1})}.$$

For solving the equilibrium allocations in the floating economy it is convenient to express private consumption and the real money variables in terms of the sequences $y(s^t)$, $\mu(s^t)$ and $x(s^t)$, with no reference to nominal variables $M(s^t)$, $P(s^t)$ or $N(s^t)$.

First, from the goods market clearing condition, eq. 14, the price level is given by

$$P(s^t) = \frac{M(s^t) - m^s(s^t)}{(1-\tau)y(s^t)} = \frac{\mu(s^t) - x(s^t)}{(1-\tau)y(s^t)}M(s^{t-1}). \tag{18}$$

Substituting $P(s^t)$ into the consumer's budget constraint (eq. 17) gives

$$c(s^t) = \left(\frac{1 - x(s^t)}{\mu(s^t) - x(s^t)}\right)(1-\tau)y(s^t) \tag{19}$$

Note that if the household is not doing any money saving ($x(s^t) = 0$), then $c(s^t) = (1 - \tau)y(s^t)/\mu(s^t)$. However in general, the money growth rate has both a direct effect on consumption and an indirect effect via $x(s^t)$.[14]

The real return to money saving (the inflation rate) is given by

$$\pi(s^{t+1}) = \frac{P(s^{t+1})}{P(s^t)} = \left(\frac{\mu(s^{t+1}) - x(s^{t+1})}{\mu(s^t) - x(s^t)}\right)\mu(s^t)\frac{y(s^t)}{y(s^{t+1})}. \tag{20}$$

In the dollarized regime, $\pi(s^t) = 1$ for all s^t, and thus the money growth rate $\mu(s^t)$ is endogenous and depends in equilibrium on households' choices regarding money savings $x(s^t)$. In the floating economy, the money growth rate $\mu(s^t)$ is the domestic government's policy choice, and the inflation rate $\pi(s^t)$ is endogenous and depends on money savings $x(s^t)$.

Making repeated use of the expression for the price level, eq. 18, real balances, real money savings, and the real value of seigniorage (corresponding to net purchases by foreigners in the dollarized regime) can be expressed, respectively as:

$$\frac{M(s^t)}{P(s^t)} = \left(\frac{\mu(s^t)}{\mu(s^t) - x(s^t)}\right)(1-\tau)y(s^t) \tag{21}$$

$$\frac{m^s(s^t)}{P(s^t)} = \left(\frac{x(s^t)}{\mu(s^t) - x(s^t)}\right)(1-\tau)y(s^t) \tag{22}$$

$$\frac{N(s^t)}{P(s^t)} = \frac{M(s^t) - M(s^{t-1})}{P(s^t)} = \left(\frac{\mu(s^t) - 1}{\mu(s^t) - x(s^t)}\right)(1-\tau)y(s^t). \tag{23}$$

Note that $x(s^t) \in [0,1]$. Setting $\mu(s^t) = 1$ implies zero seigniorage. As $\mu(s^t) \to \infty$, $\frac{N(s^t)}{P(s^t)} \to (1-\tau)y(s^t)$ and thus $c(s^t) \to 0$. Note that for $\mu(s^t) \geq 1$ seigniorage is (weakly) positive. For $\mu(s^t) < 1$, seigniorage is negative.

[14] The direct effect is that faster money growth reduces purchasing power and reduces consumption. The indirect effect is that faster money growth reduces the savings rate $x(s^t)$ (we show this in the appendix) which from eq. 19 *increases* consumption, as long as $\mu(s^t) > 1$.

3 Equilibrium

We first define equilibria for two economies that are not of direct interest, but that are useful for constructing borrowing constraints that are not too tight. The first economy is one in which: (i) the borrowing constraints $\{\underline{B}(s^t)\}$ are exogenous, and (ii) the government must respect the constraints and is not allowed to default. The second economy is one in which the government has defaulted in the past and has no access to the international debt market. The third economy, which is the economy of interest, features endogenous borrowing constraints that are not too tight. In this economy default is permitted but never occurs in equilibrium.

Equilibrium with exogenous borrowing constraints. Consider a set of constraints $\widetilde{B} = \left\{\widetilde{B}(s^t)\right\} \forall t \geq 0$ and for all s^t. A competitive equilibrium given initial assets B_{-1} and M_{-1} is a policy Λ, and an allocation rule that maps policies into prices $P(\Lambda)$ and $w(\Lambda)$ and private choices $c(\Lambda)$ and $m^s(\Lambda)$ such that for all t and s^t : (i) the household choices solve the household's problem, (ii) the government budget constraints are satisfied given initial assets B_{-1} and the constraints $\widetilde{B}$, (iii) markets clear (eqs. 12 through 14).

Post-default equilibrium. A post default equilibrium is defined in exactly the same way, except that feasibility for the government requires $B(s^t) = 0$.

We will look for borrowing constraints that are tight enough, but not too tight. They are tight enough in that if the sovereign is at the borrowing constraint, then the probability that he will strictly prefer to default in the next period is zero. They are not too tight in that there is at least one combination of shocks under which he will be indifferent between repaying or defaulting.

The government's problem is to choose a policy Λ that maximizes expected lifetime utility (eq. 1) given assets B_{-1} and M_{-1} under the associated competitive equilibrium. Let $W_{t+1}(b, (m), (s^t, s_{t+1})\ ;\ \widetilde{B})$ be a function defining the welfare under the optimal policy given history (s^t, s_{t+1}), arbitrary bonds b (and in the dollarized economy private dollars m), and a set of borrowing constraints $\widetilde{B}$. Let $D_{t+1}(b, (s^t, s_{t+1})\ ;\ \widetilde{B}))$ be a function defining the difference between the value of repaying and the value of default $V_{t+1}\left((m),(s^t,s_{t+1})\right)$:

$$D_{t+1}\left(b,(s^t,s_{t+1})\ ;\ \widetilde{B}\right) = W_{t+1}\left(b,(m),(s^t,s_{t+1})\ ;\ \widetilde{B}\right) - V_{t+1}\left((m),(s^t,s_{t+1})\right)$$

Borrowing constraints $\underline{B} = \{\underline{B}(s^t)\}$ are *not too tight* if they satisfy, for all s^t

$$\min_{s_{t+1}\in S \text{ s.t. } pr(s_{t+1}|s^t)>0} D_{t+1}(\underline{B}(s^t),\left(s^t,s_{t+1}\right)\ ;\ \underline{B}) = 0. \tag{24}$$

$W_{t+1}(b,(m),(s^t,s_{t+1})\ ;\ \widetilde{B})$ is increasing in b for any (s^t,s_{t+1}) while the value of default is independent of the quantity of debt defaulted on. Moreover, $D_{t+1}(b,(s^t,s_{t+1})\ ;\ \widetilde{B}))$ does not depend on consumers' money balances.[15] Hence, if the not-too-tight condition is satisfied, then for all m and for all $b \geq \underline{B}(s^t)$, $W_{t+1}(b,(m),(s^t,s_{t+1})\ ;\underline{B}) \geq V_{t+1}\left((m),(s^t,s_{t+1})\right)$ and the government will weakly prefer not to default.

Monetary equilibrium with competitive riskless lending. This is defined in exactly the same way as the equilibrium with exogenous borrowing constraints, except that (i) the borrowing constraints are defined by the solution to eq. 24 (i.e. they are not too tight), and (ii) at each t and s^t the government has the option of defaulting.

3.1 Characterizing optimal policy

We now describe how we solve for the optimal policies and associated allocations in our economies. Solving the government problem in the dollarized economy is simpler, because monetary policy in this case is exogenous, and the governement only needs to decide on the optimal debt policy.

The dollarized economy: Allocations in the dollarized monetary economy with riskless lending can be characterized by solving the following problem. Consider a government that maximizes expected lifetime utility (eq. 1) subject to budget constraints (eq. 10) and a set of borrowing constraints of the form $B(s^t) \geq \underline{B}^d(s^t)$..

[15]In the floating economy the nominal quantity of pesos has no impact on real allocations (we return to this point in Proposition 1) and in the dollarized economy, the government is powerless to impact the time series for private consumption.

Sufficient conditions for a solution to this problem are the optimality conditions for bonds:

$$\begin{aligned} \phi(s^t)\frac{(1-\lambda(s^t))}{g(s^t)} &\geq \beta(1+r)\sum_{s_{t+1}}\phi(s^t,s_{t+1})\frac{(1-\lambda(s^t,s_{t+1}))}{g(s^t,s_{t+1})} \\ &= \text{ if } B(s^t) > \underline{B}^d(s^t) \end{aligned} \tag{25}$$

$$\lim_{t\to\infty}\beta^t\sum_{s^t}\phi(s^t)\frac{(1-\lambda(s^t))}{g(s^t)}\left(B(s^t)-\underline{B}^d(s^t)\right)=0. \tag{26}$$

Note that in the dollarized economy, separability between private and public consumption in preferences implies that consumers and the government end up solving completely separate problems. Consumers use dollar money savings to smooth the marginal utility of private consumption through time, taking as given inflation rates. The government uses debt to smooth the marginal utility of public consumption through time, taking as given the world interest rate and state-contingent borrowing constraints.[16]

The floating economy: The following result shows that we can characterize the equilibrium in the floating economy by solving a standard consumption-savings problem subject to endogenous borrowing constraints.

Proposition 1: *The optimal policy and associated equilibrium in the floating monetary economy with riskless lending can be characterized by solving the problem of a planner who maximizes expected lifetime utility (1) subject to an aggregate resource constraint (15) and a set of "not too tight" borrowing constraints.*

Proof. See the appendix.

This result greatly simplifies the optimal policy problem because it effectively eliminates the constraint that the allocations chosen by the government must constitute a competitive equilibrium. At the simplest level, the intuition for the result is that control of the money

[16] In defining the government problem, we assume that it takes as given borrowing constraints that are not-too-tight. Could the government do better by internalizing the relationship between policy choices and not-too-tight borrowing constraints? To increase value, an alternative policy would have to imply looser borrowing constraints. However, we can argue that not-too-tight constraints can only be tighter under alternative policies. First, note that changing policy prior to default will not change default values $V_t(s^t)$. Second, since values inside the contract, $W_t(B(s^t), s^t\ ; \underline{B})$, could only be lower under alternative policies, not-too-tight borrowing constraints could only be tighter.

growth rate is equivalent to access to lump-sum taxation in this economy: by choosing money growth rates appropriately, the government can achieve any possible division of total resources between private and public consumption. Since the government's problem reduces to a standard consumption-savings problem, there is no time-consistency problem in our economies, in the sense that the government never has an incentive to deviate from its pre-announced policy.

Sufficient conditions for a solution to this planner's problem are the optimality conditions for bonds (eqs. 25 and 26) described above and an intra-temporal first order condition

$$\frac{\lambda(s^t)}{c(s^t)} = \frac{(1-\lambda(s^t))}{g(s^t)} \tag{27}$$

which says that the planner wants to equate the marginal utilities of privately and publicly provided goods at each date and state.

Combining eqs. 15 and 27 gives

$$\begin{aligned} c(s^t) &= \lambda(s^t)R(s^t) && (28)\\ g(s^t) &= (1-\lambda(s^t))R(s^t) && (29)\\ R(s^t) &= y(s^t) - B(s^t) + (1+r)B(s^{t-1}) && (30) \end{aligned}$$

Note that because the marginal utilities of private and public consumption are equated state by state, the inter-temporal first order condition (eq. 25) can be expressed in terms of total resources available for domestic consumption $R(s^t)$:

$$\begin{aligned} \frac{\phi(s^t)}{R(s^t)} &\geq \beta(1+r)\sum_{s_{t+1}} \frac{\phi(s^t, s_{t+1})}{R(s^t, s_{t+1})} \\ &= \text{ if } B(s^t) > \underline{B}^f(s^t) \end{aligned} \tag{31}$$

Thus in this case, the planner simply wants to smooth fluctuations in the endowment through time, irrespective of the process for taste shocks: a floating, credit-worthy government will typically issue debt when the endowment is relatively low, and repay when the endowment is high.

Monetary policy will be used primarily to adjust the mix between private and public consumption in response to taste shocks. When $\lambda(s^t)$ is high, indicating a preference for private consumption, the money growth rate $\mu(s^t)$ and thus seigniorage will be relatively low.[17]

3.2 Characterizing debt constraints across regimes

The 'not too tight' borrowing constraints $\underline{B}$ defined in (24) generally differ across exchange rate regimes $\underline{B}^f \neq \underline{B}^d$. Constraints tend to be looser in the regime in which debt is used more actively, which in turn depends on the nature of shocks hitting the economy. We begin by characterizing the ranking of borrowing constraints and welfare for the cases in which only one type of shock is operative.

Proposition 2. *When only preference shocks are operative,* $\underline{B}^d \leq \underline{B}^f = 0$.

Proof. When the economy faces only preference shocks, control of the money growth rate and thus the inflation rate can achieve the efficient split of constant output between public and private consumption following eq. 27. Eq. 31 indicates no remaining role for debt as long as $\beta(1 + r) = 1$. If $\beta(1 + r) < 1$, there are *ex ante* welfare gains from using debt to reallocate consumption towards the present. However, no borrowing can be supported even in this case, because a borrower would have no incentive to repay debts *ex post*.

Under dollarization, the debt instrument has value, since debt is used to smooth taste shocks (see eq. 25). Thus, borrowing can be supported in this case.

Proposition 3. *When only output shocks are operative,* $\underline{B}^f \leq \underline{B}^d = \tau \underline{B}^f \leq 0$.

Proof. See the appendix.

When only output shocks are operative, endogenous borrowing constraints in the dollarized economy are tighter than in the floating economy. The position of borrowing constraints and the equilibrium path for debt in the dollarized economy correspond to a scaled-down version of

[17] Recall that we have assumed that consumers cannot hold dollar bonds or dollar cash in the floating economy. However, this restriction is not binding prior to default. In particular, given eq. 28, a consumer's first order conditions for saving in dollar bonds and dollars would be satisfied at zero given eq. 31. However, if private dollar savings were permitted post-default, then the value of default would be larger implying tighter borrowing constraints.

the floating economy. The logic is that with only output shocks, under a float debt is used to smooth total domestic consumption, whereas under dollarization debt is used to smooth only the public component of consumption. Because debt is used more actively under a float, repayment incentives are stronger and borrowing constraints are looser.

Welfare ranking: If the economy is subject to only output shocks, a float welfare dominates because in addition to giving the government an additional instrument, more borrowing can be supported in equilibrium: $\underline{B}^f \leq \underline{B}^d$. However, if the economy is subject to only preference shocks the welfare ranking is unclear. A float achieves the efficient intra-temporal allocation of resources between public and private consumption, but dollarization allows the government to borrow more, which is beneficial when $\beta(1+r) < 1$. We conclude that a necessary condition for dollarization to be welfare-improving in our environment is that the variance of preference shocks is positive.

4 Quantitative Analysis

In this section we evaluate our model mechanisms quantitatively. We first present an extensive sensitivity analysis to understand how dollarization impacts borrowing constraints and welfare. We then calibrate our model to two countries: El Salvador and Mexico. Our model predicts that in El Salvador dollarization ought to have increased financial integration, whereas in Mexico it would not improve access to international credit.

4.1 Sensitivity

We consider a simple baseline parameterization, and conduct an extensive sensitivity analysis with respect to alternative parameter values. We assume that both shocks are drawn independently from the same two-point distribution, with a mean of 0.85 and a standard deviation of 5 percent. Thus $\lambda, y \in \{0.8075, 0.8925\}$. We set the constant tax rate τ so that absent any shocks, efficient allocations could be achieved with constant debt and a constant money supply. Thus $\tau = E[1-\lambda] = 0.15$. Finally we set the discount factor β to 0.96 and the interest rate r

to 2 percent. By exploring variations on this particular parameter configuration we will learn a lot about the differences between the two exchange rate regimes. Later we will introduce more discipline in the choice of parameter values by calibrating the model to some specific countries.

In this section we explore how borrowing constraints and welfare change as we vary (i) the variance of the taste shock λ, (ii) the correlation between λ and y, (iii) the discount factor β, and (iv) the interest rate r. Comparing borrowing constraints across regimes is easy, because in our example the position of the constraint is independent of the current state.[18] Comparing welfare is more difficult because expected lifetime utility is conditional on the date zero values for all the state variables in the economy. Moreover, in addition to the values for shocks and for sovereign debt, there is one additional endogenous state variable in the dollarized economy, namely domestic consumers' holdings of dollars. We compare welfare by (i) setting initial sovereign debt in both regimes equal to the value of the borrowing constraint in the floating economy (which almost always exceeds the constraint under dollarization), (ii) setting the real value of initial dollars in the dollarized economy equal to the real value of pesos in the floating economy, and (iii) taking an unconditional average of lifetime utility under each possible initial configuration of shocks. The welfare difference is reported as the percentage difference in lifetime aggregate consumption across regimes.[19]

At the parameter configuration described above, the borrowing constraint is extremely tight under a float, while the government can borrow almost 20% of GDP in the dollarized economy. Welfare is very similar across regimes. The intuition for these findings will become clear in the context of our sensitivity analysis.

Variance of λ **:** We first vary the variance of λ, holding all other parameters constant. The first panel in Figure 1 shows the impact on the position of the borrowing constraints as a fraction

[18] This reflects the fact that the state s^t probability of each possible next period event s_{t+1} is always strictly positive.

[19] We report welfare comparisons across regimes at the floating borrowing constraint. Increasing initial wealth in the welfare calculation would tend to favor the floating regime, since the further one starts from the constraint, the less one values additional debt capacity. We have conducted simulations in which a floating economy is allowed to costlessly (but irreversibly) dollarize at any date. If there are points in the ergodic distribution for the permanently floating economy at which expected lifetime utility is higher than in the dollarized economy, then switching to dollarization occurs in equilibrium in the economy where this is an option. We found that switches occur following histories of shocks that drive the debt level close to the constraint for the floating economy. Thus dollarization is used as a tool to acquire additional borrowing capacity when it is required.

of mean output, and relative welfare in the two economies.

First, note that the variance of λ plays no role in determining the position of the constraint or debt dynamics in the floating economy. As discussed above, this is because shocks to λ can be perfectly insured with the money growth instrument. In the dollarized economy, the borrowing constraint is looser the larger are the taste shocks, since bigger shocks increase the role for international borrowing and lending. When taste shocks are small enough, the ranking of constraints across regimes switches. This is consistent with the previous result for the economy with only endowment shocks.

How the welfare ranking across regimes changes with the variance of taste shocks is also intuitive. Obviously, when taste shocks are very small, so that more borrowing is possible in the floating regime, then a float welfare dominates: dollarizing would mean losing an instrument, with no credibility gain in financial markets. For more volatile taste shocks, there is an interesting trade-off. Figure 1 shows that when taste shocks are large enough, the welfare gain from looser borrowing constraints in the dollarized economy more than offsets the loss of seigniorage as a policy instrument, and thus dollarizing is welfare-improving.

Correlation between y and λ : The second panel in Figure 1 shows the effect of varying the correlation between endowment and taste shocks. This correlation has no impact on the position of the borrowing constraint in the floating economy for the reason discussed above: taste shocks are perfectly insured via monetary policy.

In the dollarized economy, a positive correlation between the two shocks means that when output (and tax revenue) is high, government consumption is not especially valued (and vice versa). Thus the government would like to use debt aggressively, and the threat of losing the debt instrument in the event of default is potent. Thus the higher is the shock's correlation, the looser is the endogenous borrowing constraint.

The fact that increasing the correlation of shocks loosens the borrowing constraint is one reason why a higher correlation makes dollarization relatively more attractive in welfare terms. A second reason is that for higher correlations, the loss of the monetary policy instrument under dollarization is less painful. The logic is that if y and λ co-move positively, then private income tends to rise automatically in times when private consumption is highly valued. Thus increasing $corr(y, \lambda)$ reduces the role for monetary policy.

Discount factor β : The third panel in Figure 1 shows the effect of varying β. As in standard repeated games, the more impatient are consumers, the less effective is the threatened default punishment of exclusion from international borrowing. Thus borrowing constraints become tighter as β is reduced. For sufficiently low β, no borrowing can be supported in equilibrium. This threshold β is much higher in the floating regime, reflecting the fact that in this case monetary policy perfectly insures taste shocks, and endowment shocks are small. Borrowing can be supported for a wider range of values for β in the dollarized economy, because in this regime debt has an additional valuable role smoothing preference shocks. As β increases towards the discount rate, $1/(1+r)$, the borrowing limit loosens substantially in the dollarized economy, such that when $\beta = 0.98$ it is at 27.5% of GDP, compared to 18.1% when $\beta = 0.96$.

When no borrowing can be supported in either regime, floating clearly welfare-dominates, since dollarizing means losing an instrument with no credibility gain in financial markets. The welfare gap between the two regimes narrows as β is increased over the range where the borrowing constraint is becoming looser in the dollarized economy, but is still zero in the floating economy. As the consumer's rate of time preference approaches the interest rate, the position of the borrowing constraint becomes increasingly irrelevant. The reason is that as the opportunity time cost of holding bonds shrinks, the government is willing to hold an increasingly large buffer stock of precautionary bonds, and consequently the borrowing constraint binds ever less frequently. This is why for large enough values for β, the welfare ranking across regimes flips once more.

Interest rate r : In the last panel of Figure 1 we consider the effect of varying the interest rate, r. The results are rather striking. The position of the borrowing constraint is minimally sensitive to the interest rate in the floating regime, while the constraint becomes extremely loose for low interest rates in the dollarized economy. When $r = 0.1\%$, the government can borrow up to three times GDP at a risk-free interest rate.

To build some intuition for these results, consider the trade-offs in the default decision for a government that has borrowed up to the regime-specific constraint. The gain from defaulting is that the government no longer has to roll over its debt. Lowering the interest rate makes it cheaper to roll over debt, which reduces default incentives. At the same time, however, lowering the interest rate also reduces the value of using debt policy for precautionary motives, which increases default incentives. As the gap between rate of time preference and the interest rate becomes large, an inter-temporal motive to borrow eventually dominates any smoothing or precautionary motives to save. At this point, optimal debt policy becomes entirely passive, in the sense that the government gradually borrows up to the constraint and then stays there - the ergodic distribution for debt becomes degenerate. As long as optimal debt policy becomes passive at a positive interest rate, no borrowing can be supported in equilibrium. The logic is that for any looser constraint, there would be a gain to defaulting at the constraint (reduced interest payments), but no cost. Defaulting is costless in this case because debt is optimally constant prior to default, just as it is constant (by assumption) post default.

This discussion suggests that the effect of reducing the interest rate on the not-too-tight borrowing limit will depend on how actively debt is used to adjust to shocks. In the floating regime, as we have argued previously, the only shocks relevant to debt repayment incentives are endowment shocks. These shocks are quite small, so optimal debt policy is quite passive, and becomes increasingly so as r is reduced. Thus, even though maintaining a good credit report is cheap (because r is low), there is not much incentive to do so because it is optimal to always stay close to the constraint. This is why the borrowing constraint remains very tight in the floating economy.

Under dollarization, by contrast, the government also wants to use debt to smooth preference shocks. In this case, debt is actively adjusted, even for $r = 0$. Thus, in this economy, the effect that debt repayment becomes cheaper when r is reduced is the key force in determining default incentives, and the borrowing constraint becomes ever looser. In fact, as $r \to 0$, the constraint becomes arbirarily loose, since in this case the cost of debt repayment converges to zero, while there is always a benefit from maintaining access to credit given that the ergodic equilibrium distribution of debt remains non-degenerate.[20]

[20] As we discussed previously, this entire discussion is predicated on the assumption that the government cannot

As the interest rate is reduced, the welfare gains from dollarizing become quite substantial, reaching 5.7 percent of consumption when $r = 0.1\%$. These welfare gains are too large to be attributed solely to improved smoothing of endowment shocks, since the endowment shocks are relatively small, and Lucas' (1987) expressions for the welfare costs of business cycles would suggest small welfare gains to eliminating them. Rather, the bulk of the welfare gains in this example comes from inter-temporal reallocation. Starting at the tight floating constraint, dollarizing allows the government to raise government spending in the short run by increasing borrowing. If the differential between the rate of interest and the rate of time preference is large, bringing forward consumption can generate large welfare gains. Of course, in a deterministic version of the model in which debt repayment cannot be enforced directly, these gains can never be realized because it would always be optimal to default at any hypothetical non-zero constraint. It is easier to realize these gains when dollarized, because debt plays a more important role in smoothing shocks once monetary policy is unavailable. Hence, we conclude that when the interest rate is far below the rate of time preference, there are potentially large welfare gains from dollarizing, because dollarizing endogenously strengthens repayment incentives.

4.2 Calibration

We now apply our model to the study of actual countries in which dollarization has been discussed or implemented. Given that the relative performance of the floating and dollarized regimes in terms of financial integration and welfare is very sensitive to various parameter values, it is important to consider parameterizations that are appropriate for specific countries. We calibrate to two countries: El Salvador, which dollarized in 2001, and Mexico, which retains the peso, but where dollarization has been discussed in the past (see, for example, Cooley and Quadrini, 2001). The strategy is to calibrate the model assuming a floating regime, and to then compare across exchange rate regimes holding all parameter values constant.

We solve the model at a quarterly frequency and compare annualized output from the model to the annual data that is available for these countries. The variables we focus on are real

save after default, so the Bulow and Rogoff (1989) critique does not apply.

output, government consumption, household consumption, the change in government net foreign assets, and the inflation rate. The series for output, public and private consumption and inflation are from the World Development Indicators for 1960-2002.[21] Inflation is the annual percentage change in consumer prices. To study the dynamics of foreign public debt in our model we use the series for Government Foreign Financing as a percentage of GDP from the IMF's International Financial Statistics for 1980-2002. We log the series for output and consumption, and filter all the data with a 15 year Band-Pass Filter.[22]

The stochastic structure for the shocks is country-specific. We assume that shocks to λ and y are drawn from a time-invariant bivariate lognormal distribution, with potentially correlated innovations:

$$\log(y_t) = \mu_y + \varepsilon_{y,t}$$

$$\log(\lambda_t) = \mu_\lambda + \varepsilon_{\lambda,t}$$

$$\begin{pmatrix} \varepsilon_{y,t} \\ \varepsilon_{\lambda,t} \end{pmatrix} \sim N(0, \Sigma) \qquad \Sigma = \begin{pmatrix} \sigma_y^2 & \sigma_{y\lambda} \\ \sigma_{y\lambda} & \sigma_\lambda^2 \end{pmatrix}$$

The three parameters in the variance-covariance matrix Σ are chosen so that the floating economy replicates the annualized volatilities of output and government consumption, and the correlation between government consumption and output. Shocks are discretized into a 9-state Markov process following the Tauchen and Hussey (1991) procedure.

The quarterly interest rate r is set to 1%, which is the average quarterly yield on a one-year U.S. Treasury Bill for the period 1996 to 2006. The time preference parameter β is set to 0.98, which is consistent with the 2% average quarterly interest rate in El Salvador on domestic dollar-denominated loans.[23] For the sake of simplicity, we assume the same value for β in both countries.

The parameters μ_y and μ_λ are such that the mean value for y is 1 and for λ is 0.85, implying

[21] The specific series we used from WDI are: General government final consumption expenditure, Household final consumption expenditure, GDP and Inflation. All these series (except inflation) are in per capita terms, and in real units of local currency.

[22] We use a longer filter to keep some of the lower frequency movements that have been documented by Aguiar and Gopinath (2007) to be important for emerging-markets economies.

[23] The series used is the prime lending rate in dollars for loans of more than one year, as reported by the El Salvador Central Bank, for the post-dollarization period.

government consumption around 15% of GDP. This is approximately equal to government consumption's share of output in both countries. As in the sensitivity section we assume a constant labor tax rate $\tau = 0.15$. Table 1 summarizes the parameter values used.

4.3 El Salvador

Table 2 presents business cycle statistics for the El Salvadorean data, and for the corresponding model economy under the floating and dollarized regimes. Business cycle statistics from the model are based on annualized output from a long simulation designed to approximate the limiting distribution of asset holdings. Model output is filtered in the same way as the data.

In the data, government consumption is almost twice as volatile as output and private consumption is substantially more volatile than output. In the context of our calibration procedure, this generates an important role for taste shocks. Inflation and government consumption co-move positively, and are both counter-cyclical. To replicate the counter-cyclicality of government consumption, the calibration calls for positively correlated shocks (see Table 1). The change in net foreign public assets is acyclical and negatively correlated with government consumption in the data. Thus periods of high government expenditure are associated with both higher inflation and greater foreign borrowing.

The floating regime model calibrated to El Salvador fits the data well. The model replicates the negative empirical correlation between private and public consumption, the positive correlation between inflation and government consumption, and the counter-cyclicality of inflation. Given the shock process, periods of low output - when inter-temporal smoothing dictates additional foreign borrowing - also tend to be periods when the demand for government consumption is high - and intra-temporal smoothing dictates high inflation. It follows that the model replicates the fact that inflation is counter-cyclical, and the fact that the accumulation of net foreign assets is negatively correlated with government consumption. Moreover, inflation in the model is the highest when the economy is at the borrowing constraint, because the government uses inflation to compensate for the lack of available credit.

Table 2 also presents the statistics for the dollarized regime. Dollarization increases financial integration for El Salvador. The dollarized economy is able to borrow a larger proportion of annual output (8.3 versus 7.0 percent in the floating regime).[24] The looser borrowing limit under dollarization reflects the fact that under a float, monetary expansions are positively correlated with increased borrowing, so under dollarization, debt is adjusted more actively, as reflected in a more volatile net foreign asset position. Interestingly, average public external debt relative to GDP in El Salvador increased from 0.24 pre-dollarization (1970-2001) to 0.30 post-dollarization (2002-2007).

Dollarization also reduces the frequency of financial crises, defined as periods in which the borrowing constraint is binding: the probability mass at the constraint is 10% under a float compared to 6% when dollarized. Because more active use of debt in the dollarized regime is a good substitute for the loss of the inflation instrument, government consumption exhibits similar volatility across regimes. In the dollarized economy, the sovereign wants to borrow when output is low or when the taste for government consumption is high. Since these events tend to coincide in the El Salvador calibration, a single instrument can go a long way towards accommodating both sources of risk. We find that although expected welfare under the dollarized regime is very similar to the floating regime, for some shock combinations dollarization can improve welfare (by around 0.1% of lifetime consumption). In light of the sensitivity analysis, the reason why dollarization looks quite attractive is twofold: (i) taste shocks are large, and (ii) taste and productivity shocks are positively correlated.

Average money savings - in excess of those dictated by the cash-in-advance constraint - are quite small in these economies, on the order of one percent of annual GDP. Nonetheless, adjustment of money savings is quite a powerful instrument for smoothing the marginal utility of private consumption inter-temporally. One indication of the role played by money comes from comparing the volatilities of output and private consumption in the dollarized economy. In the absence of money saving, the consumer's budget constraint would reduce to $c(s^t) = (1-\tau)y(s^{t-1})$, in which case private consumption and output would be equally volatile. In contrast, in the monetary equilibrium the percentage standard deviation of output is 5.27, while

[24] Recall from the discussion in Section 2 that debt limits are relatively tight in our model, because exclusion from debt markets is the only punishment for default.

the corresponding figure for private consumption is 4.37. Note also that on average there is more demand for money when dollarized than under a float. This does not reflect a difference in the average inflation rate across regimes. Rather private consumers compensate for the absence of monetary policy as a device for buffering shocks by engaging in additional precautionary saving and self-insurance.

4.4 Mexico

Table 3 presents business cycle statistics for the data in Mexico and for the corresponding models. Consumption and output are roughly equally volatile in Mexican data, while government consumption is much more volatile than output. Inflation has been extremely volatile. In terms of correlations, the Mexican economy differs dramatically from El Salvador's. In Mexico, the correlations between private consumption, public consumption and output are all strongly positive. In further contrast to El Salvador, the change in net foreign assets is positively correlated with output and weakly positively correlated with government consumption. Thus the Mexican government tends to borrow and lower inflation in recessions, while in booms it inflates and repays debts.

Our calibration suggests that in Mexico taste shocks are smaller than in El Salvador. Replicating the large positive correlation between government spending and output requires taste shocks that are negatively correlated with output, the opposite of the pattern for El Salvador. The result is that periods of expansionary monetary policy tend to be periods of contractionary debt policy.

As was the case with El Salvador, the floating economy calibrated to Mexico successfully matches many features of the data. Output and private and public consumption are strongly positively correlated with each other. In our formulation of taste shocks, an increase in λ makes agents simultaneously value private consumption more and public consumption less, which tends to make the correlation between the two negative. Productivity shocks, by contrast, induce a positive correlation. Because productivity shocks are the most important source of risk for Mexico, the model reproduces the strong positive correlation between public and private consumption observed empirically.

The floating model economy also predicts a positive correlation between inflation and government spending, in line with Mexican data. A positive correlation emerges because the government finances taste-shock driven fluctuations in government consumption by adjusting the inflation tax rate. However, because periods of high output tend to be periods of high demand for government consumption ($\rho_{\lambda y} < 0$), the inflation rate does not have to fluctuate too much to deliver the efficient level of government consumption. This is why the model fails to account for the high volatility of inflation observed in Mexico. The model does match the pro-cyclicality of changes in foreign assets because debt is used to smooth output fluctuations: the government runs down its assets in periods of low output, and engages in precautionary savings in periods of relatively high output.

Table 3 also presents statistics for the dollarized economy. Dollarization reduces international financial integration for Mexico by several metrics: the borrowing constraint is much tighter, the change in net foreign assets is much less volatile, and the frequency of periods in which the constraint binds is greater. Given the calibrated pattern of shocks for Mexico, dollarization makes debt less useful, since periods of high output, which call for debt repayment, also tend to be periods of high demand for government consumption, which call for borrowing when they cannot be financed through inflation. It comes as no surprise that borrowing constraints are tighter under dollarization, while welfare is lower, on average by 0.2% of lifetime consumption.

5 Historical Experience

In the context of our theory, a country's choice for its exchange rate regime has implications for the volatility of its inflation rate, and for its ability to sell bonds in international sovereign debt markets. In practice, easier access to international credit should translate into some combination of additional borrowing or lower sovereign risk spreads. In this section we provide some empirical evidence that is consistent with the hypothesis that by surrendering monetary independence a government can effectively improve its credit rating as a sovereign borrower.

We first look at the experiences of four countries that recently delegated monetary policy offshore: Italy and Portugal, which adopted the European single currency in 1999, and Ecuador and El Salvador, which dollarized in 2000 and 2001 respectively. Figure 2 plots time series for sovereign spreads for loans issued by these four countries.[25] Spreads are defined as the difference in yields between domestic and foreign government issued bonds, where paired bonds share similar maturities, coupon rates and currency. In each case, we are able to isolate default risk from devaluation risk by pairing bonds denominated in the same currency. For example, we compare the yield to maturity on a deutsche mark (DM) denominated bond issued by Italy to a DM denominated bond issued by Germany.

Italy and Portugal are interesting case studies among the set of European countries participating in the Economic and Monetary Union (EMU) because in addition to having issued foreign currency bonds that are traded in secondary markets, they have lived with very high levels of government debt relative to GDP: 116% and 95% respectively in 1996. The European single currency was officially introduced on January 1st 1999, but more relevant for markets' perceptions of default risk is the date when it became clear that these countries would be allowed to adopt the euro at the new currency's inception. For Italy, Bassetto (2006) argues that 1996 was the key year. The first panel of Figure 2 shows that spreads on Italian deutsche mark denominated bonds decreased substantially in that year, by about 100 basis points in total. The second panel plots spreads for Portuguese bonds. As in the Italian case, spreads on these bonds also decreased significantly in 1996 and 1997.[26]

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 in late 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. Figure 2 shows that default risk increased significantly in

[25] Data for Italy and Portugal are from Bloomberg. Italian bonds are matured in 12-31-97 and 12-31-06 respectively. The Portuguese bond matured 7-02-03. We do not report spreads when the time to maturity drops below one year. Ecuador's spread is the JP Morgan Emerging Market Bond Index (EMBI) Spread for Ecuador. Data for El Salvador are the difference between the domestic dollar prime interest rate on loans of maturity greater than one year and the yield on a U.S. government bill with one year maturity. We use this spread measure for El Salvador because El Salvador issued its first Global Bonds in international markets only in 2001.

[26] Bernoth, von Hagen and Schuknecht (2006) document that spreads on newly issued DM-denominated bonds decreased prior to the start of EMU for all member countries.

1998 prior to the 1999 crisis and default. In July 2000 spreads came down again after Ecuador dollarized and renegotiated its debts. Since the dollarization plan was implemented, spreads on Ecuadorian government bonds have decreased cumulatively by about 800 basis points.

El Salvador implemented its dollarization plan in 2001. Figure 2 shows that the spread on dollar loans has decreased by over 400 basis points since 2001. In fact the very day after the new currency was adopted, the interest rate on consumer mortgages fell from 17 to 11 percent. Consumer credit has been growing, and the government and the corporate sector have benefited from cheaper international borrowing.

Thus, in time series data for countries that have surrendered monetary policy, the evidence is consistent with the thesis that this reform has reduced the cost of international credit. We now turn to cross-sectional data, and consider a much larger set of countries. Here we find complementary evidence that countries with less flexibility in setting monetary policy - as evidenced by having a more stable exchange rate - are viewed as safer borrowers.

We study the relationship between exchange rate volataility and default risk for 63 countries that are rated by Moody's and that also have data on nominal effective exchange rates. Moody's International Investor Ratings are intended to convey default risk for foreign currency sovereign bonds. We use credit ratings as opposed to direct measures of spreads as our proxy for ease of access to international credit because ratings are available for a broader set of countries (in practice, ratings and spreads correlate very strongly). For each country in our sample, we compute the standard deviation of the growth rate of nominal effective exchange rates with annual data over the period 1985-2000. The data is taken from the International Financial Statistics.

Table 4 presents results from regressing international investor ratings in 2000 on the standard deviation of exchange rate growth rates for the sample of countries. All standard errors are robust to heteroskedasticity. The table shows that countries with more volatile exchange rate growth have worse investor ratings. In the univariate regression, the exchange rate volatility coefficient is negative and statistically significant at the 1% level.[27] We then add dollar GDP per capita in 2000 as an additional control and find that the standard deviation of exchange rate growth

[27] A similar relation emerges when considering the relation between the standard deviation of CPI inflation and investor ratings.

remains negative and statistically significant. The table also indicates that richer countries tend to have better ratings.[28] This cross-sectional evidence is consistent with the notion that greater flexibility in exchange rate policy can reduce access to international credit.

6 Conclusion

This paper analyzes the interaction between the choice of exchange rate regime and integration in international financial markets. The advantage of a floating regime is that control of the money growth rate and thus of seigniorage constitutes a flexible policy instrument for cushioning shocks. At the same time, dollarization may be attractive precisely because eliminating the monetary instrument can strengthen incentives to repay debts, and thereby increase access to international credit. This is a new way to think about how relinquishing monetary independence may strengthen credibility. It is a complement to the existing literature, which has largely focused on dollarization as a source of external credibility in environments in which monetary independence would lead to excessive inflation.

We find that the historical experience of countries that have delegated control of monetary policy is consistent with the idea that dollarizing can make it easier for a country to borrow. In particular, countries that recently adopted the dollar or the euro experienced a decline in the cost of sovereign borrowing around the time the regime change was announced.

An important message from this analysis is that the effect of dollarization on financial integration and on welfare depends critically on the type of shocks economies face, and on the level of international interest rates. Low interest rates make dollarization especially attractive, because debt becomes a very cheap instrument for smoothing fluctuations. We also find that economies in which monetary policy and debt policy are optimally synchronized will likely experience the greatest gains from relinquishing control of monetary policy.

When calibrating our model to actual countries, El Salvador, which dollarized in 2001, appears a better candidate for dollarization than Mexico, because the model predicts that elimi-

[28] We tried adding external debt to GDP ratio as an additional control in the regression, but it was not statistically significant.

nating the monetary instrument should allow El Salvador to borrow more, and Mexico to borrow less. Extending the model to incorporate a richer structure for production and a larger set of instruments for the government would allow for a more refined quantitative assessment of the trade-off introduced in this paper. However, the intuition developed for the conditions under which dollarization increases financial integration should still apply in more general environments. In particular, more borrowing will be possible when dollarized as long as the sovereign wants to adjust debt more aggressively in response to shocks, to compensate for the absence of an independent monetary policy.

We conclude by noting that while the decision of whether to conduct an independent monetary policy or to adopt another country's currency is a very important one, the basic economic mechanisms we emphasize in this paper have much broader potential application. In related work, Krueger and Perri (2005) study the connection between the extent of government insurance against idiosyncratic risk at the household level, and the depth of private domestic credit markets. They find that progressive taxation can increase incentives to default on private debts, and thus crowd out private insurance. In the international arena, there are various examples of international policy choices that shrink a country's choice set for domestic policy, and which may thereby increase a country's access to international credit. One example is the decision to joint a customs union, such as the North American Free Trade Area, which requires candidate member countries to give up control of taxes on trade. A second example is the Economic and Monetary Union in Europe, which requires eliminating restrictions on cross-border flows of capital and labor and thus limits countries' ability to respond to shocks by adjusting domestic tax rates. In these and many other examples the theory outlined in this paper suggests a connection between the extent of domestic economic sovereignty and the treatment a country can expect in sovereign debt markets.

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Figure 1: Borrowing Constraints and Welfare

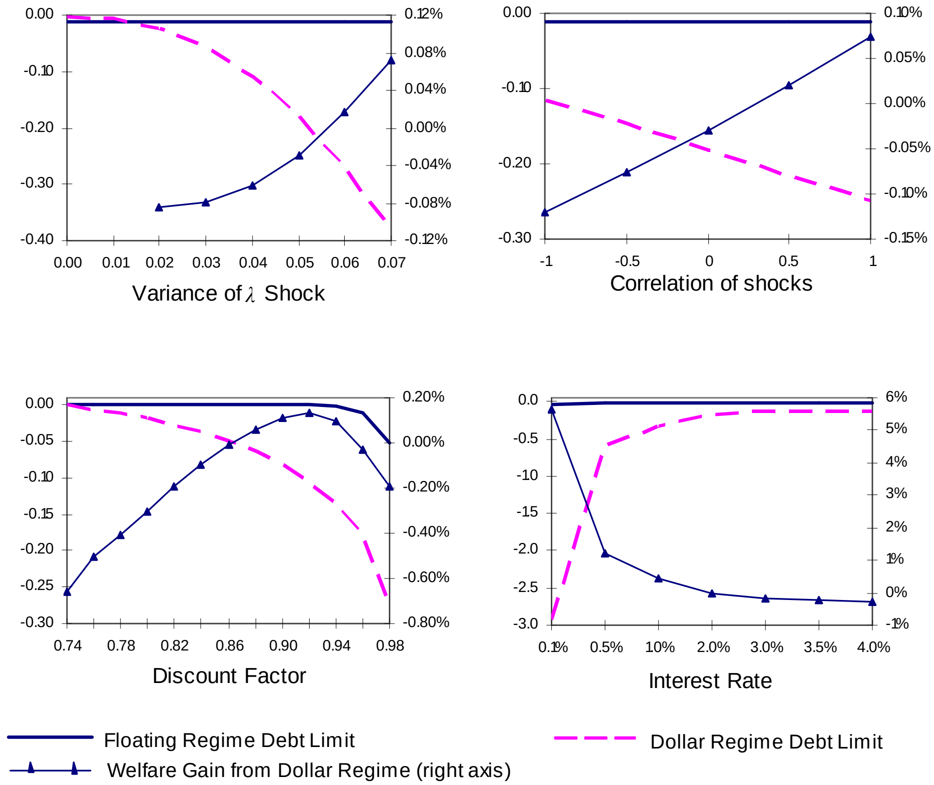

Figure 2: Spreads and Dollarization

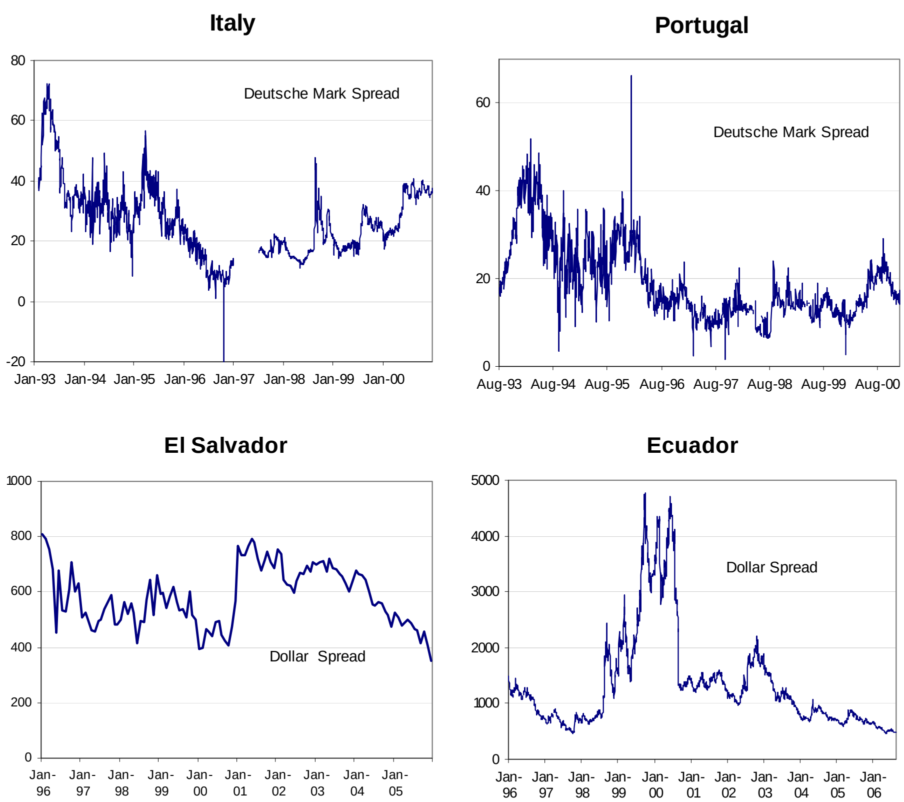

Table 1: Calibration

Country-specific parameters		El Salvador	Mexico
std. dev. output	σ_y	0.105	0.0787
std. dev. pref. shock	σ_λ	0.035	0.013
shock correlation	$\sigma_{y\lambda}/\sigma_y\sigma_\lambda$	0.372	-0.524
Common parameters			
mean pref. shock	$E[\lambda]$	0.85	
interest rate	r	0.01	
labor tax rate	τ	0.15	
discount factor	β	0.98	

Table 2: Business Cycle Statistics, EL SALVADOR

	Data			Floating Economy			Dollarized Economy		
variable (x)	std(x)	cor(x,y)	cor(x,g)	std(x)	cor(x,y)	cor(x,g)	std(x)	cor(x,y)	cor(x,g)
Output (y)	5.27	–	-0.05	5.27	–	-0.05	5.27	–	-0.05
Govt. cons. (g)	9.73	-0.05	–	9.74	-0.05	–	8.30	-0.05	–
Private cons.	7.58	0.90	-0.38	4.68	0.81	-0.25	4.37	0.79	0.11
Inflation	4.46	-0.29	0.19	8.92	-0.22	0.68	–	–	–
Δ NFA (public)	0.48	0.03	-0.19	3.11	0.67	-0.25	3.27	0.54	-0.84
Borrowing constraint / GDP (%)				7.01			8.31		
Mean money savings / GDP (%)				0.80			1.20		
Mean debt / GDP (%)				3.96			6.40		
Frequency constraint binds (%)				10.0			6.0		

Table 3: Business Cycle Statistics, MEXICO

	Data			Floating Economy			Dollarized Economy		
variable (x)	std(x)	cor(x,y)	cor(x,g)	std(x)	cor(x,y)	cor(x,g)	std(x)	cor(x,y)	cor(x,g)
Output (y)	3.95	–	0.78	3.95	–	0.79	3.95	–	0.79
Govt. cons. (g)	5.67	0.78	–	5.66	0.79	–	3.76	0.79	–
Private cons.	3.84	0.94	0.67	2.83	0.80	0.69	3.37	0.76	0.77
Inflation	19.10	-0.09	0.24	5.84	0.24	0.40	–	–	–
Δ NFA (public)	1.31	0.41	0.14	2.10	0.64	0.28	0.30	0.35	-0.17
Borrowing constraint / GDP (%)				3.47			0.66		
Mean money savings / GDP (%)				0.38			0.66		
Mean debt / GDP (%)				1.66			0.19		
Frequency constraint binds (%)				12.1			14.8		

Table 4: Institutional Investor Ratings Regressions

Std. of Exchange Rate	-27.04***	-5.24*
	(3.80)	(2.69)
log(GDP per capita)		3.32***
		(0.29)
R^2	0.38	0.83
Number of countries	63	63

Appendix

Proof of Proposition 1.

We want to show that the government in the monetary economy, in which control of the money growth rate is the only way to reallocate resources between the public and private sectors, can achieve the same allocations as a planner who can effectively use lump-sum taxes and transfers to redistribute freely period by period. In particular, we need to show that there exist sequences for the money growth rates $\mu(s^t)$, associated savings rates $x(s^t)$, and inflation rates $\pi(s^t)$ that satisfy (i) the consumer's budget constraint (eq. 19) given the planner's target values for private consumption (eq. 28) (ii) the government's budget constraint (eq. 7) given the planner's target values for government consumption (eq. 29), (iii) the conditions for household optimization (eqs. 5 and 6).

Consider an arbitrary future date and state, T and s^T, and an arbitrary feasible monetary policy from s^T onwards. For our desired decentralization result it is sufficient to show that for all s^t and for all $t \leq T$ the planner in the monetary economy can implement any value for $c(s^t) \in (0, R(s^t))$, where total resources $R(s^t)$ are given by eq. 30, given an appropriate choice for $\mu(s^t)$.

To show this we begin by making a few useful observations.

1. Because this is an endowment economy, neither money growth nor inflation have any distortionary effects on factor supplies.

2. Past monetary policy does not restrict the set of feasible allocations that can be achieved looking forward, because current and future policy determine the real value of the pesos consumers carry into the period, which is what matters for real allocations.[29]

Given T and s^T we first show that the government can implement any value for $c(s^T) \in \left(0, R(s^T)\right)$, and in particular can implement the target value from eq. 28. We then work backwards to compute the value for $\mu(s^{T-1})$ that delivers the target $c(s^{T-1})$, exploiting the fact that changes in $\mu(s^{T-1})$ do not impact $c(s^{T-1}, s_T)$. In this fashion we can work backwards all the way to period 0, along the way deriving sequences for $\mu(s^t)$, $\pi(s^{t+1})$ and $x(s^t)$ that decentralize the planner's solution.

We guess, and will verify, that given a particular monetary policy from tomorrow onwards, there will be a critical money growth rate $\overline{\mu}(s^t)$ such that for any $\mu(s^t) \geq \overline{\mu}(s^t)$ the money savings rate $x(s^t)$ is constant and equal to zero, while for $\mu(s^t) < \overline{\mu}(s^t)$ the savings rate $x(s^t)$ is continuous and decreasing in $\mu(s^t)$, with the property that $x(s^t) \to 0$ as $\mu(s^t) \to \overline{\mu}(s^t)$.

[29] The real purchasing power of consumers' money balances entering the goods market at (s^t, s_{t+1}) is given by

$$\frac{M(s^t)}{P(s^t, s_{t+1})} = \left(\frac{1}{\mu(s^t, s_{t+1}) - x(s^t, s_{t+1})}\right)(1-\tau)y(s^t, s_{t+1})$$

and thus does not depend on $\mu(s^t)$ or $x(s^t)$.

If the target value for $c(s^t)$ is less than or equal to

$$\overline{c}(s^t) = \frac{(1-\tau)y(s^t)}{\overline{\mu}(s^t)}.$$

then from the consumer's budget constraint (19) it can be implemented with a money growth rate $\mu(s^t)$ defined by

$$\mu(s^t) = \frac{(1-\tau)y(s^t)}{c(s^t)}. \tag{32}$$

where $\mu(s^t) \geq \overline{\mu}(s^t)$ and $x(s^t) = 0$. In this case, the lower is the target value for $c(s^t)$, the higher is the required $\mu(s^t)$. As $\mu(s^t) \to \infty$, $c(s^t) \to 0$. From eq. 20 the inflation rate $\pi(s^{t+1})$ in this case is given by

$$\pi(s^{t+1}) = \left(\mu(s^{t+1}) - x(s^{t+1})\right) \frac{y(s^t)}{y(s^{t+1})}. \tag{33}$$

If the target value for $c(s^t)$ is greater than $\overline{c}(s^t)$, then it will not be possible to implement in a monetary economy without money savings. In this case, the required money growth rate will be low or negative, savings $x(s^t)$ will be positive, and the inter-temporal first order condition for money saving will be an equality. From eq. 19, $c(s^t, s_{t+1}) > 0$ implies $\mu(s^t, s_{t+1}) > x(s^t, s_{t+1})$ for all s_{t+1}. Given the expressions 19 and 20 for current consumption and the inflation rate between t and $t+1$ the inter-temporal first order condition implicitly defines $x(s^t)$ as a continuous function of $\mu(s^t)$. In particular, the inter-temporal first order condition may be written

$$\frac{\lambda(s^t)}{c(s^t)} = \beta \sum_{s_{t+1}} \frac{\phi(s^t, s_{t+1})}{\phi(s^t)} \frac{\lambda(s^t, s_{t+1})}{c(s^t, s_{t+1}; \Lambda_{t+1})} \frac{(\mu(s^t) - x(s^t))\, y(s^{t+1})}{\mu(s^t)\,(\mu(s^t, s_{t+1}; \Lambda_{t+1}) - x(s^t, s_{t+1}; \Lambda_{t+1}))\, y(s^t)} \tag{34}$$

Using eq. 19 to express consumption as a function of $x(s^t)$ and $\mu(s^t)$ gives

$$\frac{\lambda(s^t)\mu(s^t)}{(1 - x(s^t))\,(1-\tau)} = \beta \sum_{s_{t+1}} \frac{\phi(s^t, s_{t+1})}{\phi(s^t)} \frac{\lambda(s^t, s_{t+1})}{c(s^t, s_{t+1}; \Lambda_{t+1})} \frac{y(s^{t+1})}{(\mu(s^t, s_{t+1}) - x(s^t, s_{t+1}; \Lambda_{t+1}))} \tag{35}$$

It is immediate from this expression that the savings rate $x(s^t)$ is everywhere decreasing in $\mu(s^t)$.[30] For $\mu(s^t) \leq \overline{\mu}(s^t)$, given (i) a continuation policy Λ_{t+1}, (ii) future money growth rates $\mu(s^t, s_{t+1})$, (iii) future savings rates $x(s^t, s_{t+1}; \Lambda_{t+1})$, and (iv) future consumption $c(s^t, s_{t+1}; \Lambda_{t+1})$, the current money growth rate $\mu(s^t)$ is defined by the solution to eq. 35 when the money savings rate $x(s^t)$ is given by re-arranging eq. 19, i.e.

$$x(s^t) = \frac{c(s^t)\mu(s^t) - (1-\tau)y(s^t)}{c(s^t) - (1-\tau)y(s^t)} \tag{36}$$

[30] Here is some intuition for the response of $x(s^t)$ to $\mu(s^t)$. Absent a change in the savings rate, a reduction in the money growth rate $\mu(s^t)$ reduces the current price level $P(s^t)$ and increases expected inflation $\pi(s^{t+1})$, which tends to reduce savings. It also increases current consumption, and reduces the marginal utility of consumption, making consumers want to save more. With no change in the savings rate the second effect would dominate, leaving the marginal utility of consumption at s^t too low (see 35). Of course, in equilibrium prices and decisions adjust so that the household's inter-temporal first order condition is satisfied. The equilibrium adjustment mechanism is that the expected inflation rate rises by more than under the no-savings-adjustment hypothsis, and the savings rate rises. This increase in the savings rate is consistent with the inflation dynamic, and the reduced return to saving reduces the right hand side of the intertemporal first order condition. At the same time, a higher savings rate actually increases equilibrium consumption (see eq. 19), reducing the left hand side of the first order condition, but for log utility the first effect dominates.

The critical money growth rate $\overline{\mu}(s^t)$ is the value of $\mu(s^t)$ that solves 35 when $x(s^t) = 0$. For $\mu(s^t) > \overline{\mu}(s^t)$ the inter-temporal first order condition will be a strict inequality with $x(s^t) = 0$, confirming the guess that for money growth rates exceeding $\overline{\mu}(s^t)$, household maximization will imply no money saving.

The important point relating to our decentralization result is that with log utility the savings rate $x(s^t)$ is uniformly decreasing in the money growth rate $\mu(s^t)$. The implication is that if the government had infinite resources, it could make seigniorage arbitrarily small and consumption arbitrarily large by reducing $\mu(s^t)$ towards the point at which $x(s^t) = \mu(s^t)$ (see eq. 19). In practice, the government always has at least $R(s^t) - (1-\tau)y(s^t)$ resources from direct taxation and international borrowing. So it can reduce the money growth rate to the point at which seigniorage is equal to the negative of this number, in which case $c(s^t) = R(s^t)$. Thus we have shown that the monetary authority can implement any value for $c(s^t) \in (0, R(s^t))$ with an appropriate choice for $\mu(s^t)$. QED.

Corollary: Equilibrium uniqueness

There is a unique monetary equilibrium in our economy. This follows immediately from the fact that the savings rate $x(s^t)$ is everywhere decreasing in $\mu(s^t)$. In particular, for any policy Λ_{T+1} defining policy from period $T+1$ and onwards, each possible money growth rate $\mu(s^T)$ at s^T implies a unique value for $x(s^T)$ and thus for $c(s^T)$ and $\pi(s^T, s_{T+1})$. A similar argument can be applied, recursively, at each date $t \leq T$.

Proof of Proposition 3.

Let $\underline{B}^f$ and $B^f(s^t)$ denote the equilibrium borrowing constraints and path for debt holdings in the floating economy subject only to output shocks. Now consider a new output path for a scaled-down version of the floating economy, $\widehat{y}(s^t) = \tau y(s^t)$, $\forall s^t$. Because preferences are homothetic, the equilibrium constraints and debt holdings for this scaled-down economy are $\widehat{\underline{B}}^f = \tau \underline{B}^f$ and $\widehat{B}^f(s^t) = \tau B^f(s^t)\ \forall s^t$.

Now consider the dollarized economy. Let $\underline{B}^d$ and $B^d(s^t)$ denote the equilibrium borrowing constraints and path for debt holdings in the dollarized economy. We will conjecture (and later verify) that $\underline{B}^d = \widehat{\underline{B}}^f$. Given $\widehat{\underline{B}}^f$, our constructed path for debt $\widehat{B}^f(s^t)$ satisfies the first-order condition for debt in the dollarized economy, eq. 25, when λ is constant. Thus, if $\underline{B}^d = \tau \underline{B}^f$ then $B^d(s^t) = \tau B^f(s^t)$.

Now we show that indeed $\underline{B}^d = \tau \underline{B}^f$. For this step it is sufficient to note that if debt holdings in the dollarized regime are given by $\tau B^f(s^t)$, then the difference between the value of the Ramsey equilibrium and the value of default is proportional to the difference in the floating regime for any initial state (B_{-1}, s_0). In particular, with only output shocks, $D^d(B_{-1}, s_0) = (1-\lambda) D^f(\tau B_{-1}, s_0)$ (this claim can be easily verifed by expanding the value functions under both regimes for the given sequence of debt holdings). Therefore, if $\underline{B}^f(s_0)$ is the solution to $D^f(\underline{B}^f, s_0) = 0$ for any s_0, then $\underline{B}^d(s_0) = \tau \underline{B}^f(s_0)$ is the solution to $D^d(\tau \underline{B}^f, s_0) = 0$. Finally, note that since $\underline{B}^f \leq 0$, $\underline{B}^f \leq \tau \underline{B}^f$. QED.

Allowing for de-dollarization

In certain regions of the parameter space, we will show that dollarized economies face looser borrowing constraints than floating economies because default is relatively more costly. Does this result rely on our assumption that exchange rate regimes are permanent? We now consider what would happen if, post default, a dollarized economy could pay a one-time fixed cost φ and switch to a float (a more complete analysis would endogenize this cost).

If $\varphi = 0$, then the whole motivation for dollarizing collapses: a dollarized defaulter would immediately float, and thus dollarizing could not possibly increase credibility in debt markets. Alternatively, if $\varphi > \overline{\varphi}$ it would never be optimal to move to a float, where $\overline{\varphi} > 0$ defines the largest cost at which a defaulter is indifferent between remaining dollarized or floating for at least one combination of shocks (we have implicitly assumed $\varphi \geq \overline{\varphi}$ up to this point). Note that unless taste shocks are very large, $\overline{\varphi}$ will be small, reflecting small potential welfare gains from intra-temporal reallocation (in the spirit of Lucas, 1987).

For $\varphi \in (0, \overline{\varphi})$, a dollarized economy would move to a float, post default. For a given level of debt, default incentives are now defined by the relative values of (i) repaying versus (ii) defaulting, paying φ, and floating. The ranking of "not-too-tight" constraints across regimes depends on the size of φ. If φ is large enough, constraints in the dollarized economy are tighter than when switching is ruled out, but still looser than under a float. To understand this, note that as $\varphi \to \overline{\varphi}$, the dollarized constraints converge to those in the original no-switching economy. Thus, it is not essential to the story of this paper that dollarization is irreversible.