Excessive Dollar Borrowing in Emerging Markets

Balance Sheet Effects and Macroeconomic Externalities

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Abstract

Emerging market economies that borrow in dollar are prone to severe financial crises that involve a financial accelerator, i.e. a feedback loop of depreciating exchange rates, deteriorating balance sheets and declining aggregate demand. This paper shows that such financial accelerator effects create an externality that induces individual borrowers to undervalue the social risks of dollar debt and take on too much of it. Specifically, atomistic rational agents take the extent of exchange rate depreciations during crises as given. They realize that dollar debt entails large repayments and cut-backs in spending in crisis states, but they do not internalize that the resulting reduction in aggregate demand leads to further depreciations in the exchange rate. These depreciations in turn deteriorate balance sheets and tighten borrowing constraints across the economy, hurting other borrowers. We discuss the merits of various policy measures to correct this distortion and conclude that a reserve requirement on dollar debt is the most desirable.

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1 Introduction

Foreign currency denominated debts have played an integral role in the emerging market crises of the past quarter century.[1] As a result, it is often suggested that it would be efficient for emerging market economies to reduce their exposure to dollar debt so as to lower the risk of suffering a crisis.[2]

From the standpoint of individual borrowers, however, the choice between local currency debt and dollar debt is a private tradeoff between risk and return: exchange rates are on average counter-cyclical, so local currency debt insures against aggregate fluctuations, but it commands an interest rate premium since international lenders are averse to emerging market risk. When borrowers choose the currency composition of their debt portfolio, they weigh the expected cost of fluctuations in consumption against any savings from the interest rate spread between the local currency and the dollar.

If borrowers have rational expectations and choose to take on the risk of holding dollar debt, why should this decision not be socially efficient? In other words, why should it not be efficient for countries to experience financial crises in some unfortunate states of nature?

This paper offers an answer to this question based on the existence of a risk externality: Decentralized agents in emerging markets take on excessive dollar debts because they fail to internalize the contribution of their borrowing decisions to the financial accelerator that is triggered during crises.

This accelerator arises when borrowing constraints depend endogenously on the value of firms' collateral, which introduces a positive feedback loop between economic activity and the level of the exchange rate: First, exchange rate depreciations reduce the dollar value of firms' collateral, which tightens borrowing constraints, forces them to cut back on their spending and reduces aggregate demand. Secondly, lower aggregate demand depreciates the exchange rate.

Decentralized agents have rational expectations regarding the exchange rate and internalize the first part of this feedback loop, but since they are atomistic they take the economy's exchange rate as given and do not internalize the second part, which constitutes a pecuniary externality. In perfect markets pecuniary externalities do not matter, but in the economy examined here the level of the exchange rate determines the valuation of domestic agents' collateral, and depreciations tighten borrowing constraints. Hence the pecuniary externality has real effects. The resulting pro-cyclical fluctuations in the country's external borrowing capacity lie at the heart of most third-generation models of currency crises (see e.g. Krugman, 1998, 1999; Chang and Velasco, 2001), which underlines the practical relevance of our results.

The existing literature has shown that the described feedback loop between economic activity and endogenous borrowing constraints can qualitatively and quantitatively explain the sharp declines in economic activity and current account reversals that characterize emerging market crises (see e.g. Mendoza, 2006). These works have taken

[1] This is maintained by the theoretical literature on third generation currency crises (see e.g. Krugman, 1998, 1999; Schneider and Tornell, 2004; Jeanne and Zettelmayer, 2005) and corroborated by a growing empirical literature (see e.g. Levy Yeyati, 2006; Mauro et al., 2007).

[2] We use the convention to refer to all forms of foreign currency denominated debt as 'dollar debt.'

the widespread use of dollar debt in emerging markets as given. Our contribution is to show that the financing decisions of decentralized agents are biased towards excessive dollar debt precisely because they fail to internalize the feedback effects involved in the financial accelerator. In other words, the existing literature on financial crises has shown that dollar debt magnifies the financial accelerator; we complement that analysis by showing that the financial accelerator magnifies incentives for taking on dollar debt.

The literature has offered three main categories of explanations for why emerging market borrowers take on large amounts of dollar debt. First, Caballero and Krishnamurthy (2003) show that the interaction of a friction in ex-ante insurance markets with borrowing constraints leads to excessive dollar borrowing in emerging markets.[3] Our result, by contrast, holds under complete ex ante insurance markets and relies on a single friction: a borrowing constraint in the credit relationship with international lenders. Many researchers argue that this friction has been the key factor behind most emerging market crises (see e.g. Calvo, 1998; Krugman, 1999). The decentralized equilibrium in our setup is *constrained inefficient*, i.e. a social planner who reduces dollar borrowing makes everybody in the economy better off.[4]

A second strand of the literature on dollar borrowing that is complementary to our explanation emphasizes distortions introduced by government. Krugman (1998) and Schneider and Tornell (2004) show that private agents take on risky forms of finance such as dollar debt because of moral hazard, e.g. in order to take advantage of bailout guarantees. While some of the risk-taking in emerging markets is certainly attributable to these explanations, this cannot satisfactorily explain the high level of dollar debt that could be observed in firms that were unlikely to be bailed out (Eichengreen and Hausmann, 1999). Chamon (2003) and Broda and Levy Yeyati (2006) show that in the absence of strict enforcement of seniority rules, local currency creditors can be expropriated by taking on additional dollar debt. Jeanne (2003) and Tirole (2003) focus on incentives of government to inflate local currency debt as a reason why local currency debt is harder to obtain for emerging market economies.

A third category of explanations that was suggested by Eichengreen and Hausmann (1999) is that international capital markets are incomplete and markets for emerging market local currency debt simply do not exist. However, over the past decade, markets in such bonds have developed considerably (Burger and Warnock, 2006), and in historical perspective borrowing in local currency has been very common in emerging markets (Reinhart and Rogoff, 2008). A more accurate description might be that markets for local currency debt do exist, but that such debts are subject to a risk premium. This is the modeling approach that we will take in our paper.

Our work is also related to a strand of the literature that examines the efficiency of external borrowing decisions in the presence of market imperfections. Uribe (2006) shows that the allocations of atomistic borrowers in economies with exogenous borrowing constraints are constrained efficient no matter whether the constraints are imposed

[3] Lorenzoni (2008) demonstrates in a closed economy paper with a related mechanism that the interaction of these two frictions can lead to socially excessive investment.

[4] In Caballero and Krishnamurthy (2003), a social planner who reduces external dollar borrowing redistributes profits from domestic borrowers to domestic lenders. The authors assume that domestic agents do not know ex ante whether they will be borrowers or lenders in the domestic credit market so that this redistribution constitutes a Pareto improvement.

at the individual or at the aggregate level. Our paper illustrates that this efficiency result no longer holds when borrowing constraints are endogenously dependent on the real exchange rate. As in the theoretical works of Stiglitz (1982) and Geanakoplos and Polemarchakis (1986), the incompleteness of markets in an economy with multiple commodities (i.e. tradable and non-tradable goods) leads to pecuniary externalities that entail socially inefficient competitive allocations.

Our externality result applies to decentralized equilibria, but does not extend to the borrowing choices of a monopolist or of a government that fully internalizes the pecuniary externalities it creates.[5] In most recent emerging market crises, foreign currency debts were amassed by a large number of private agents.

We discuss a number of policy remedies to correct the externality to dollar debt. In general, any policy measure that disrupts the financial accelerator mechanism can address the distortion. Examples for such first-best measures include policies to alleviate borrowing constraints, such as better creditor protection, and policies that stabilize exchange rates in low output states.

Among second-best policy options, our preferred measure is a tax on external dollar borrowing in the form of an unremunerated reserve requirement (URR) on dollar debt. This instrument can uniquely and robustly implement the social optimum. In a sample calibration of our model, we find that the externality is of a magnitude of 1.25% per dollar lent in the decentralized equilibrium. The social optimum could be restored by a reserve requirement that, in equilibrium, would impose a cost of only 0.66% per dollar lent, since such a tax would induce decentralized agents to shift towards local currency debt, which would lower macroeconomic volatility and reduce the externality associated with dollar debt.

In contrast to the existing literature that focuses on firm-level currency mismatches (see e.g. Goldstein and Turner, 2004), our findings imply that such a tax should also apply to firms in the tradable sector that suffer from no mismatches in the denomination of their assets and liabilities, since the externality that we identify is of a macroeconomic nature.

We also compare the insurance properties of local currency denominated debt with GDP-linked dollar debt. While the two instruments offer similar insurance characteristics in normal times, local currency debt better protects better against financial crises, because during crises the exchange rate typically declines more strongly than GDP.

The setting in which we analyze the problem is a small open emerging market economy with three time periods, labeled 0, 1 and 2, and two goods, tradables and non-tradables. We interpret the relative price of the two goods as a measure of the economy's real exchange rate.

In period 0, small domestic agents borrow from international lenders to finance investment.They have to allocate their debts between dollars and local currency, which are represented by the price of tradable and non-tradable goods. In period 1, domestic agents produce both tradable and non-tradable goods. An aggregate shock affects

[5]The externality would also arise in oligopolistic settings: an oligopolist who is responsible for x% of a country's borrowing and who holds x% of the country's collateral would leave 100 − x% of the externality uninternalized.

productivity in the tradable sector and by extension domestic income and aggregate demand in the emerging market economy.[6] While the market for tradables always clears since international demand for tradable goods is perfectly elastic, the real exchange rate has to adjust in order to equilibrate supply and demand in the non-tradable sector. In case of a negative shock, for example, aggregate demand for non-tradable goods falls and their relative price has to decline (i.e. the real exchange rate depreciates). As a result, the price of non-tradables is pro-cyclical, i.e. the real exchange rate appreciates in high states and depreciates in low states.

By implication, repayments on foreign currency debt are highest in the lowest states of nature, and vice versa. This exacerbates the impact of aggregate shocks. Specifically, the greater a country's dollar liabilities, the steeper the decline in aggregate demand in response to a negative shock of a given magnitude and the stronger the depreciation in its exchange rate. By contrast, repayments on local currency debt move in parallel with aggregate demand, mitigating the impact of aggregate shocks. In our model setup, the assumption that tradable and non-tradable goods enter in Cobb-Douglas fashion implies that the price of non-tradables is linear in aggregate consumption and that risk markets for the small open economy are effectively complete.

Lenders charge a risk premium on domestic currency debt because they are averse to emerging market risk. Borrowers trade off this risk premium against the insurance benefits of local currency debt, leading to an interior optimum in which the small open economy is imperfectly insured against aggregate shocks. This creates a potential for financial accelerator effects and the associated externality.

A negative shock to the economy reduces aggregate demand, depreciates the exchange rate and reduces international lenders' valuation of domestic collateral. If the shock is of sufficient magnitude, it triggers binding borrowing constraints and a financial accelerator: binding constraints imply that agents have to cut back on consumption, which reduces aggregate demand, depreciates the exchange rate even more and tightens constraints further. Decentralized agents take the level of the exchange rate as given and hence fail to internalize the full social costs of dollar debt. As a result they engage in socially excessive dollar borrowing.

The remainder of our paper is organized as follows. Section 2 describes the basic model setup. In section 3, we solve for the decentralized equilibrium. We show that a higher fraction of dollar debt in the economy increases macroeconomic volatility for given fundamentals. Section 4 solves for the social optimum and demonstrates the central externality result of the paper. We also provide a numerical example. Section 5 discusses policy implications and presents our recommended second-best policy measure, a reserve requirement on dollar debt. Section 6 concludes.

[6]This can be thought of e.g. as a productivity slowdown in the tradable sector, as experienced by Thailand in 1996/97, or as a devaluation of a trading partner or a competitor in export markets, which affected other East Asian countries after Thailand's devaluation and Argentina after Brazil's devaluation.

2 Model Setup

2.1 Analytical Environment

In our analytical model, we describe the portfolio choice between dollar and local currency-denominated debt in a small open emerging market economy. We assume that there are three time periods, labeled by $t = 0, 1, 2$, and two sets of agents: (i) the emerging market economy is inhabited by a continuum of domestic agents of mass 1, (ii) there is a continuum of international lenders, who are large in comparison to the emerging market. We discuss each in detail below.

There are two perishable goods in the economy, tradable goods T and non-tradable goods N. Tradable goods can be moved costlessly across borders and can be used for external borrowing and lending transactions. Non-tradable goods have to be consumed in the domestic economy in the period they are produced. The prices of the two goods are denoted by $p_{T,t}$ and $p_{N,t}$. We choose tradables as the numeraire so that $p_{T,t} \equiv 1$. By implication, $p_{N,t}$ represents the price of non-tradables relative to tradables, which we interpret as a measure of the real exchange rate.[7]

The economy is subject to a random productivity shock that depends on the state of nature $\omega \in \Omega$, where Ω is the set of potential outcomes. This shock is realized at the beginning of period 1 and is observed by all agents.

2.2 Domestic Agents

Domestic agents are risk averse and obtain utility from consuming tradable goods $C_{T,t}$ and non-tradable goods $C_{N,t}$ according to the utility function

$$U = E\left\{\sum_{t=1}^{2} \beta^t \hat{u}(C_t)\right\} \qquad \text{where} \qquad C_t = C_{T,t}^{\sigma} C_{N,t}^{1-\sigma} \tag{1}$$

E is the expectations operator, β represents agents' discount factor, and $\hat{u}(\cdot)$ is their period utility function, which satisfies $\hat{u}'' < 0 < \hat{u}'$. C_t is a Cobb-Douglas aggregator of tradable and non-tradable consumption, where the parameters σ and $1 - \sigma$ are the expenditure shares of tradables and non-tradables in agents' optimal consumption bundle.[8]

We assume that agents are born with an initial amount of wealth W_0 (which can be negative). They need to invest a fixed amount of tradables $\bar{I}$ in both periods 0 and 1. As a return on their investment, they receive a bundle of tradable and non-tradable

[7]The precise definition of the real exchange rate is in terms of a composite basket of tradable and non-tradable goods. However, for simplicity we follow a common practice in the theoretical literature that refers to the relative price $p_{N,t}$ itself as the real exchange rate.

[8]While our externality result holds for any utility function in which tradables and non-tradables are ordinary goods, the Cobb-Douglas specification implies that the real exchange rate is a linear function of the output shock, which allows us to obtain closed-form solutions for consumption.

goods of $(Y^\omega_{T,t}, \bar{Y}_N)$.[9] The fixed amounts of production reflect that production factors cannot be re-allocated instantaneously in response to the shock. Instead, relative prices have to adjust, i.e. the real exchange rate appreciates or depreciates.

The period 1 output of tradables $Y^\omega_{T,1}$ is subject to the aggregate productivity shock ω. This shock can stem e.g. from a general slowdown in productivity growth in that sector or from an adverse terms-of-trade shock, such as a devaluation in a neighboring country or a fall in the world market price of the country's main exports. The expected value of first period output equals $E[Y^\omega_{T,1}] = \bar{Y}_T$. For simplicity, suppose that tradable production $Y^\omega_{T,2}$ in period 2 is constant and also equals to $\bar{Y}_T$. (Our results are unchanged if we allow for period 2 uncertainty.)

In the given representative agent framework, there is no scope for a domestic credit market, since agents are identical and have a common, stricly concave utility function. However, agents can access international capital markets and issue foreign currency debt F_t and local currency debt L_t. We normalize both forms of debt to yield one unit of tradables in period $t-1$. Foreign currency debt F_t mandates an unconditional repayment of $R^* F_t$ units of tradables in period t, where the interest rate R^* is determined on world markets. The repayment $R^\omega_{L,t}$ on a unit of local currency debt is indexed to the real exchange rate, i.e. is proportional to the price of non-tradables $p^\omega_{N,t}$, which depends on the realization of the domestic productivity shock. (Even though foreign creditors can only move tradable goods from/to the emerging market economy, the value of repayments can be made contingent on the price of non-tradable goods.)

We denote the budget constraints for domestic agents in periods 0, 1, and 2 as

$$\bar{I} = W_0 + F_1 + L_1 \tag{2}$$

$$C^\omega_{T,1} + p^\omega_{N,1} C^\omega_{N,1} + \bar{I} = Y^\omega_{T,1} + p^\omega_{N,1}\bar{Y}_N - R^* F_1 - R^\omega_{L,1} L_1 + F^\omega_2 + L^\omega_2 \tag{3}$$

$$C^\omega_{T,2} + p^\omega_{N,2} C^\omega_{N,2} = \bar{Y}_T + p^\omega_{N,2}\bar{Y}_N - R^* F^\omega_2 - R^\omega_{L,2} L^\omega_2 \tag{4}$$

2.3 Borrowing Constraints

We capture the effects of credit market imperfections in the emerging market economy by assuming that borrowers are subject to a moral hazard problem. After choosing how much to borrow in period 1, they have an option to invest in a fraudulent scheme that allows them to renege on their debts in the following period. (For example, they might invest in assets that are different from what was agreed upon and that are harder to seize, or they might set up a shell company that funnels money out of lenders' reach). Lenders can detect this and can fight the scheme in court before the transaction is completed, but because of imperfect legal enforcement they can seize at most a fraction κ of the agent's income. The agent's borrowing choices are therefore subject to the

[9] We could interpret the given model as an endowment economy. However, the requirement to invest $\bar{I}$ is a natural motivation for the need to borrow in period 1, which makes the potential of binding borrowing constraints in that period relevant. Endogenizing the amount of investment and output does not change the main result of the paper – agents equalize the expected marginal product of investment to their private cost of dollar debt, ignoring the effects on exchange rate volatility, and therefore borrow excessively in dollars.

following incentive-compatibility constraint:

$$F_2^\omega + L_2^\omega \leq \kappa(Y_{T,1}^\omega + p_{N,1}^\omega \bar{Y}_N) \tag{5}$$

The term $p_{N,1}^\omega$ in the collateral constraint is what can make exchange rate depreciations contractionary: a declining real exchange rate $p_{N,1}^\omega$ reduces the dollar value of non-tradable income and collateral and therefore tightens borrowing constraints. It is common for international lenders to grant loans against non-tradable collateral, as discussed e.g. in (Mendoza, 2005) or as documented by the importance of real estate loans in many financial crises. [10]

Our setup contains three implict simplifying assumptions to enhance tractability: (i) We assume that the total amount of period 0 borrowing $F_0 + L_0$ is pre-determined, e.g. by agents' optimal consumption-investment trade-off or by another binding borrowing constraint in period 0. Therefore we do not explicitly include a borrowing constraint in period 0 that would be analogous to equation (5) in our setup. Our results are robust to deviations from this structure. (ii) We abstract from the possibility of bankruptcy, as financial markets in our setup are complete and borrowing constraints guarantee that incentives for repayment are always met. Explicitly accounting for bankruptcy would not change our externality result. (iii) We denote financial contracts as one-period contracts. However, all allocations (including the state-contingent period 1 borrowing choices) can be thought of as being determined at time 0. This implies that long-term debt contracts do not alter the set of feasible allocations for domestic agents.[11]

In summary, domestic agents maximize lifetime utility (1) subject to the budget constraints (2), (3), (4) for each of the three time periods and to the borrowing constraint (5) in period 1.

2.4 International Lenders

International capital markets are populated by a continuum of competitive risk-averse lenders that are large in comparison to the small open emerging market economy. They value payoffs according to the pricing kernel M_1^ω, which is negatively correlated to the emerging economy's productivity shocks, i.e. $\text{Corr}(M_1^\omega, Y_{T,1}^\omega) < 0$, implying that lenders are averse to emerging market risk. This is supported by empirical evidence (see e.g. Cunningham et al., 2001; Dodd and Spiegel, 2005) and is a standard assumption in the recent emerging market business cycle literature (see Arellano, 2008; Lizarazo, 2008) to capture international investors' behavior toward emerging market risk. In equilibrium, the returns $R_{i,t}^\omega$ on any asset i in which international lenders invest satisfy the pricing

[10] For analytical simplicity we have assumed a moral hazard problem here that leads to a borrowing constraint that is linear in current income. Similar results hold in other models where the borrowing limit depends on future income, as demonstrated e.g. in Korinek (2009a). More generally, higher income and net worth imply that agents have a larger stake in their projects and more to lose. This generally reduces the moral hazard and adverse selection problems that underlie borrowing constraints (Stiglitz and Weiss, 1981).

[11] Domestic agents face the same incentive problems in period 1 regarding period 2 repayment no matter whether the repayments were contracted as long-term debt in period 0 or as short-term debt in period 1.

condition

$$E\left\{R_{i,t}^{\omega}M_t^{\omega}\right\}=1 \tag{6}$$

This condition implies that international lenders supply risk-free dollar debt F_1 and F_2^{ω} perfectly elastically at the interest rate $R^*=1/E[M_t^{\omega}]$, up to the point where borrowing constraints bind. For simplicity we assume the dollar interest rate R^* constant over time.

We define ρ as a measure of the risk premium on local currency debt in period 1 so that

$$(1-\rho)E[R_{L,1}^{\omega}]=R^*$$

The payoff $R_{L,1}^{\omega}$ of local currency debt expressed in terms of tradable goods is linear in the real exchange rate and is in expectation $\frac{R^*}{1-\rho}$, according to this definition of ρ. Simple no-arbitrage considerations then imply that the state contingent payoff of local currency debt satisfies

$$R_{L,1}^{\omega}=\frac{R^*}{1-\rho}\cdot\frac{p_{N,1}^{\omega}}{E[p_{N,1}^{\omega}]} \tag{7}$$

Substituting this expression into lenders' equilibrium pricing condition $E[R_{L,1}^{\omega}M_1^{\omega}]=1$, we find that

$$\rho=-R^*\mathrm{Cov}\left(\frac{p_{N,1}^{\omega}}{E[p_{N,1}^{\omega}]},M_1^{\omega}\right) \tag{8}$$

International lenders only require compensation for holding risk that is negatively correlated with their pricing kernel M_1^{ω}. Since there is no uncertainty in period 2, local and foreign currency debt L_2^{ω} and F_2^{ω} both yield the same riskless return R^*, and one of the two securities is redundant. W.l.o.g. we set $L_2^{\omega}=0$.

3 Decentralized Equilibrium

Given international lenders' pricing kernel M_t^{ω}, a competitive equilibrium in the emerging market economy can be characterized as an allocation $(C_t^{\omega},C_{T,t}^{\omega},C_{N,t}^{\omega},F_t^{\omega},L_t^{\omega})$ and a bundle of prices and returns $(p_{N,t}^{\omega},R^*,R_{L,t}^{\omega})$ for $t=1,2$ and for all $\omega\in\Omega$, which solve domestic agents' optimization problem (1) given their budget constraints (2) to (4) and the borrowing constraint (5), which are consistent with international lenders' pricing condition (6), and which clear goods markets in the three time periods $t=0,1,2$ and for all states $\omega\in\Omega$, i.e.

for non-tradables: $$C_{N,t}^{\omega}=\bar{Y}_N$$

for tradables:

$$\begin{aligned}\bar{I}&=W_0+F_1+L_1\\ C_{T,1}^{\omega}+\bar{I}&=Y_{T,1}^{\omega}-R^*F_1-R_{L,1}^{\omega}L_1+F_2^{\omega}+L_2^{\omega}\\ C_{T,2}^{\omega}&=\bar{Y}_T-R^*F_2^{\omega}-R_{L,2}^{\omega}L_2^{\omega}\end{aligned}$$

We substitute for first period dollar borrowing F_1 and tradable consumption $C_{T,1}^{\omega}$ using the period 0 and 1 budget constraints (2) and (3) in the decentralized agent's maximization problem (1) to obtain the Lagrangian

$$\mathcal{L}^{DE} = E\Big\{\hat{u}\left([Y^{\omega}_{T,1} + p^{\omega}_{N,1}(\bar{Y}_N - C^{\omega}_{N,1}) - \bar{I} + R^*(W_0 - \bar{I}) + L_1\left(R^* - R^{\omega}_{L,1}\right) + F^{\omega}_2]^{\sigma}[C^{\omega}_{N,1}]^{1-\sigma}\right)$$
$$+ \beta\hat{u}\left([\bar{Y}_T + p^{\omega}_{N,2}(\bar{Y}_N - C^{\omega}_{N,2}) - R^* F^{\omega}_2]^{\sigma}[C^{\omega}_{N,2}]^{1-\sigma}\right)$$
$$- \lambda^{\omega}\left[F^{\omega}_2 - \kappa\left(Y^{\omega}_{T,1} + p^{\omega}_{N,1}\bar{Y}_N\right)\right]\Big\} \quad (9)$$

where λ^{ω} is the state-contingent multiplier on the borrowing constraints. Decentralized agents maximize this expression with respect to non-tradable consumption $C^{\omega}_{N,t}$, local currency debt L_1 and second-period borrowing F^{ω}_2. In doing so, they take the aggregate price of non-tradables $p^{\omega}_{N,t}$ as well as the return on local currency $R^{\omega}_{L,1}$ in each state ω as given.

In the following, we employ a recursive solution strategy. We first describe the determination of the exchange rate and the payoffs on local currency and solve for the sub-equilibrium in periods 1 and 2, given a choice of debt composition (F_1, L_1) in period 0. Then, we employ this solution to analyze agents' optimal choice of dollar versus local currency debt in period 0.

3.1 Determination of the Real Exchange Rate

The first order condition of the Lagrangian (9) with respect to $C^{\omega}_{N,t}$ describes equilibrium in the market for non-tradable goods and can be stated as

$$p^{\omega}_{N,t} = \frac{1-\sigma}{\sigma} \cdot \frac{C^{\omega}_{T,t}}{C^{\omega}_{N,t}} = \varsigma \cdot \frac{C^{\omega}_{T,t}}{\bar{Y}_N} \quad (10)$$

For the second step we defined $\varsigma = \frac{1-\sigma}{\sigma}$ to save on notation, and we used the market clearing condition for non-tradables, which requires that demand equals the given supply $C^{\omega}_{N,t} = \bar{Y}_N$. The fixed amount of non-tradable production captures the notion that production factors cannot instantaneously be reallocated across sectors in response to shocks – instead, prices have to adjust.

As described in condition (10), equilibrium in the market for non-tradable goods requires that the real exchange rate $p^{\omega}_{N,t}$ is proportional to the economy's absorption of tradables $C^{\omega}_{T,t}$.[12] If for example a negative shock to agents' production of tradables $Y^{\omega}_{T,1}$ occurs, tradable goods become scarcer and non-tradable goods relatively more abundant. For equilibrium to be restored, the relative price of non-tradables $p^{\omega}_{N,1}$ has to fall – the real exchange rate depreciates. Similarly, if tightening external borrowing constraints force agents to repay their debts and reduce new borrowing, they have to increase net exports and cut back on tradable consumption $C^{\omega}_{T,1}$, whereas their consumption of non-tradable goods remains constant (non-tradable production is fixed

[12] The simple linear relationship stems from the Cobb-Douglas aggregator in the utility function (1) and proves to be a very useful property in the following analysis. For other utility functions, we would obtain a non-linear but still monotonic relationship between $p^{\omega}_{N,t}$ and $C^{\omega}_{T,t}$ so long as both goods are ordinary; our basic externality result would still hold.

in the short run and cannot be shipped overseas). Again, the relative price of non-tradables $p^{\omega}_{N,1}$ has to fall. Loosely speaking, the price of non-tradables is pro-cyclical in aggregate consumption.

An important implication of this finding is that local currency debt fully spans the agent's consumption risk – even if there are arbitrarily many states of the world.[13] The economy in our model therefore exhibits complete markets except for the borrowing constraint (5) that limits the total amount of period 1 borrowing.

We can insert condition (10) for the real exchange rate into (7) and (8) to obtain the following equilibrium expressions for the return on local currency debt $R^{\omega}_{L,1}$ and the risk premium ρ:

$$R^{\omega}_{L,1} = \frac{R^*}{1-\rho} \cdot \frac{C^{\omega}_{T,1}}{E[C^{\omega}_{T,1}]} \tag{11}$$

$$\rho = -R^* \cdot \mathrm{Cov}\left(\frac{C^{\omega}_{T,1}}{E[C^{\omega}_{T,1}]}, M^{\omega}_1 \right) \tag{12}$$

The first expression captures that the payoff of local currency debt is a linear function of domestic agents' consumption of tradable goods, since the value of the local currency moves in tandem with aggregate consumption. This implies that local currency debt makes risk markets for domestic agents effectively complete: its payoffs can perfectly insure domestic agents against the consumption risk they face; they have to pay back more on local currency debt precisely in those states when their consumption is high, and pay back less when their consumption is low.

The second equation expresses lenders' risk premium as a function of how much domestic tradable consumption (which drives the exchange rate) covaries with the pricing kernel M^{ω}_1 of lenders. The more negatively correlated domestic tradable consumption is with lenders' marginal utility, the higher the risk premium that lenders demand as a compensation for taking on local currency debt.

Let us apply two transformations before we continue our analysis. First, we substitute the utility function $\hat{u}(\cdot)$ by the following reduced-form function

$$u(C_T) = \hat{u}(C_T^{\sigma} C_N^{1-\sigma}) = \hat{u}(C_T^{\sigma} \bar{Y}_N^{1-\sigma}) \tag{13}$$

where we take advantage of the fixed supply of non-tradables and the market clearing condition $C^{\omega}_{N,t} = \bar{Y}_N$. Second, we define the variable

$$N = L_1 \cdot \frac{E[R^{\omega}_{L,1}]}{E[C^{\omega}_{T,1}]} = L_1 \cdot \frac{R^*}{(1-\rho)E[C^{\omega}_{T,1}]}$$

Whereas L_1 measures the amount of local currency debt in units of tradable goods, N is the expected repayment on local currency debt as a fraction of total tradable consumption. Local currency debt provides insurance against consumption risk, so we can think of N as the amount of insurance that agents take on relative to their expected

[13] See Korinek (2009b) for a more general analysis of this result.

level of consumption. Using this notation for N and substituting the return on local currency debt (11) in the agent's period 1 budget constraint (3), we can express his first-period consumption of tradables as

$$C_{T,1}^{\omega} = Y_{T,1}^{\omega} - (1+R^*)\bar{I} + R^* W_0 - N\left\{C_{T,1}^{\omega} - (1-\rho)E[C_{T,1}^{\omega}]\right\} + F_2^{\omega} \tag{14}$$

This formulation illustrates that for a given amount of total borrowing, raising N, i.e. increasing the fraction of debt denominated in local currency, is equivalent to swapping the risky consumption stream $C_{T,1}^{\omega}$ against lenders' certainty equivalent $(1-\rho)E[C_{T,1}^{\omega}]$.

3.2 Euler Equation

Taking the first order condition of maximization problem (1) with respect to F_2^{ω}, we obtain the agent's Euler equation, which describes his optimal intertemporal consumption allocation. Using the transformed utility function from above, and making the customary assumption that $\beta R^* = 1$, this can be written in the standard format

$$u'(C_{T,1}^{\omega}) = u'(C_{T,2}^{\omega}) + \lambda^{\omega} \tag{15}$$

Slack Borrowing Constraints

Let us first analyze the case that borrowing constraints are not binding, i.e. $\lambda^{\omega} = 0$. The Euler equation (15) implies that $u'(C_{T,1}^{\omega}) = u'(C_{T,2}^{\omega})$, i.e. domestic agents set F_2^{ω} in every state such as to smooth out the shock and perfectly equalize consumption over the two periods, $C_{T,1}^{\omega} = C_{T,2}^{\omega} = \bar{Y}_T - R^* F_2^{\omega}$. This results in an optimal amount of borrowing

$$F_2^{\omega} = \frac{\bar{Y}_T - C_{T,1}^{\omega}}{R^*} \tag{16}$$

We use this to solve (14) for the agent's unconstrained level of consumption $C_{T,1}^{\omega,\text{unc}}$ as a function of the output shock $Y_{T,1}^{\omega}$ and the level of insurance N:

$$C_{T,1}^{\omega,\text{unc}} = \frac{\bar{Y}_T + R^* Y_{T,1}^{\omega} - R^*(1+R^*)\bar{I} + (R^*)^2 W_0 + (1-\rho)NR^* E[C_{T,1}^{\omega}]}{1+R^*(1+N)} \tag{17}$$

Consumption is less sensitive to productivity shocks the more local currency debt domestic agents have taken on. This is illustrated in figure 1. The higher L_1 or N (recall that the latter is a linear transformation of the former), the flatter the lines in the figure, i.e. the less consumption responds to the productivity shock $Y_{T,1}^{\omega}$. As a result, consumption becomes less volatile. We can confirm this analytically by computing the standard deviation of expression (17):

$$\text{Std}(C_{T,1}^{\omega}) = \frac{R^*}{1+R^*(1+N)} \cdot \text{Std}(Y_{T,1}^{\omega})$$

This expression is decreasing in the fraction of local currency-denominated debt N. As the real exchange rate $p_{N,1}^{\omega}$ is linear in tradable consumption, a higher fraction of non-tradable debt also decreases the variance of the real exchange rate and by implication reduces the risk premium on the country's local currency.

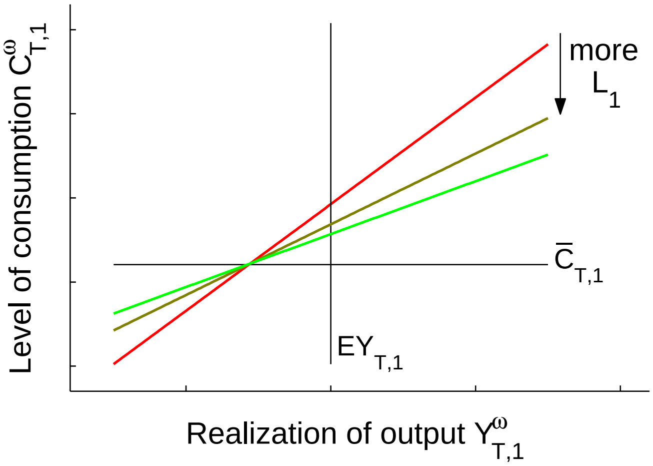

Figure 1: Consumption $C^{\omega}_{T,1}$ as a function of the output shock $Y^{\omega}_{T,1}$ for different levels of local currency debt L_1

The figure also illustrates another feature: from decentralized agents' perspective, taking on more local currency debt is equivalent to swapping the random payoff $C^{\omega}_{T,1}$ against lenders' certainty equivalent $(1-\rho)E[C^{\omega}_{T,1}] = \bar{C}_{T,1}$. To show this result analytically, we need to consider that the variables $C^{\omega}_{T,1}$, ρ, and $E[C^{\omega}_{T,1}]$ are all endogenous in general equilibrium. Taking the derivative of expression (17) with respect to N, we find that

$$\frac{dC^{\omega,\text{unc}}_{T,1}}{dN} = -\frac{R^*}{1+R^*(1+N)}\left[C^{\omega}_{T,1} - \bar{C}_{T,1}\right]$$

where it can be shown that

$$\bar{C}_{T,1} = \frac{d(1-\rho)NE[C^{\omega}_{T,1}]}{dN} = (1-\rho)E[C^{\omega}_{T,1}]$$

Increasing the amount of insurance N reduces borrowers' consumption in every state ω by the random payoff $C^{\omega}_{T,1}$ and replaces this by the constant payoff $\bar{C}_{T,1}$, which is lenders' certainty equivalent. In the figure, the result is that borrowers' consumption seems to rotate around the point $\bar{C}_{T,1}$ when the amount of insurance N is raised: local currency debt increases income and consumption in low states with $C^{\omega}_{T,1} < \bar{C}_{T,1}$ and reduces income and consumption in high states with $C^{\omega}_{T,1} > \bar{C}_{T,1}$. The following proposition summarizes our observations.

Proposition 1 *The higher the fraction of its debt that a country denominates in local currency, the lower is the variance of consumption and of the real exchange rate; as a result, the lower is the risk premium that international lenders charge on local currency.*

Note that our result of higher exchange rate volatility in the presence of dollar debt describes an economy in the absence of central bank intervention. In practice, central banks in such economies often stabilize or peg exchange rates to keep the value of foreign currency debts fixed. This has been dubbed 'fear of floating' by Calvo and Reinhart (2002). However, the property that is essential for our externality result is that exchange rates depreciate sharply in the rare event of strongly negative shocks, i.e. during financial crises. This seems to be the case even in countries that officially peg their exchange rate, as evidenced by numerous emerging market crises over the past quarter century.

Binding Borrowing Constraints and the Financial Accelerator

Agents in our model engage in borrowing so as to smooth consumption over time. As a result, the demand for borrowing is decreasing in the output shock $Y^{\omega}_{T,1}$, as indicated by equation (16). By contrast, the maximum supply of loans is increasing in the output shock, as given by the borrowing constraint (5). This implies that there is a threshold value of output $\hat{Y}_{T,1}$ such that the constraint is binding for realizations of the shock with $Y^{\omega}_{T,1} \leq \hat{Y}_{T,1}$.[14] We denote the associated level of consumption by $\hat{C}_{T,1}$.

When the borrowing constraint is binding, the shadow value $\lambda^{\omega} > 0$, and F^{ω}_2 is limited to the constrained amount

$$F_2^{\omega,\text{con}} = \kappa \left(Y^{\omega}_{T,1} + p^{\omega}_{N,1} \bar{Y}_N \right) = \kappa \left(Y^{\omega}_{T,1} + \varsigma C^{\omega}_{T,1} \right) \tag{18}$$

where we obtain the last result from substituting the equilibrium exchange rate (10). The maximum amount that an agent can borrow is an increasing function of aggregate consumption $C^{\omega}_{T,1}$, since higher consumption appreciates the exchange rate and by implication raises the value of the agent's non-tradable collateral.

This positive relationship between borrowing capacity and consumption introduces a financial accelerator effect into the economy that is responsible for the central externality result of this paper: If an economy experiences a negative shock that causes borrowing constraints to bind, the constraint forces domestic agents to reduce their borrowing and cut back on consumption $C^{\omega}_{T,1}$. Lower spending entails a depreciation in the exchange rate, which tightens borrowing constraints further, as captured by equation (18). The two effects lead to a contractionary cycle of depreciating exchange rates and tightening borrowing constraints, until the lower level of period 1 consumption is consistent with the tightened borrowing constraint. This involves a steep decline in aggregate demand, the exchange rate as well as in external borrowing (i.e. a current account reversal). All three effects are typical features of emerging market financial crises.

Analytically, we can find the resulting equilibrium by solving the system of two equations (14) and (18) for the constrained level of period 1 consumption $C^{\omega,\text{con}}_{T,1}$ as a function of the output shock and the amount of local currency debt contracted:

$$C^{\omega,\text{con}}_{T,1} = \frac{(1+\kappa) Y^{\omega}_{T,1} - (1+R^*)\bar{I} + R^* W_0 + (1-\rho) N E[C^{\omega}_{T,1}]}{1 + N - \kappa\varsigma} \tag{19}$$

When financial accelerator effects are at work, agents' borrowing capacity has to fall at a slower pace than their consumption for the economy to converge to a non-degenerate equilibrium. The technical condition for this to hold is $1 + N - \kappa\varsigma > 0$.

[14] See appendix A.1 for the derivation of this threshold.

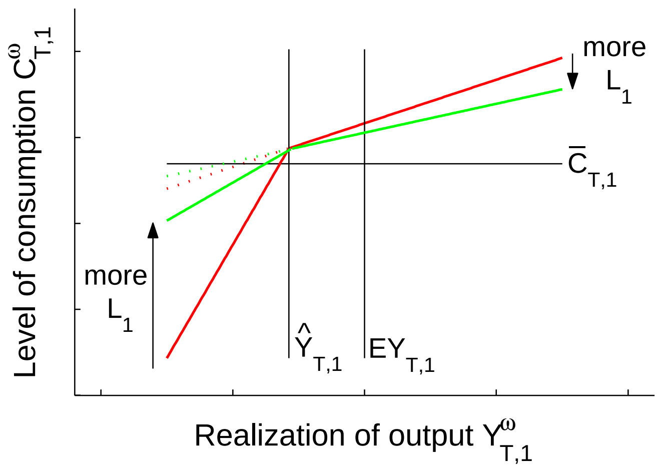

Figure 2: Consumption $C^{\omega}_{T,1}$ as a function of the output shock $Y^{\omega}_{T,1}$ when borrowing constraints are binding below a threshold $\hat{Y}_{T,1}$

We can see from (19) that consumption volatility diverges to infinity as this expression approaches zero. Given the Inada conditions on the domestic agent's utility function, optimizing agents will always choose a level of local currency debt N that guarantees that the condition is satisfied. This is consistent with the empirical finding in Bleakley and Cowan (2008) that the contractionary balance sheet effects of exchange rate depreciations are ultimately outweighed by equilibrating 'competitiveness' effects.

Figure 2 provides a graphical illustration of the effects of local currency debt on consumption volatility in an economy where borrowing constraints are binding in low states. In states in which the constraint is slack, i.e. for $Y^{\omega}_{T,1} \geq \hat{Y}_{T,1}$, agents can adjust their borrowing so as to smooth the impact of the output shock over time. On the other hand, when borrowing constraints are binding, i.e. for $Y^{\omega}_{T,1} < \hat{Y}_{T,1}$, the response of consumption to output shocks is magnified by the financial accelerator effect.

We noted earlier that when consumption declines, the exchange rate depreciates in parallel and the real burden of debts denominated in local currency falls. This implies that when borrowers have take on local currency debt, part of the adjustment to tighter borrowing constraints takes the form of lower repayments to international lenders rather than lower domestic consumption. As a result of the smaller decline in consumption, the exchange rate depreciates less, and the feedback effects that underlie the financial accelerator effect are mitigated.

Analytically, the sensitivity of consumption to output shocks is captured by the following simple derivatives of expressions (17) and (19):

$$\frac{dC^{unc}_{T,1}}{dY^{\omega}_{T,1}} = \frac{R^*}{1+R^*(1+N)} \qquad \frac{d^2C^{unc}_{T,1}}{dY^{\omega}_{T,1}dN} = -\left(\frac{R^*}{1+R^*(1+N)}\right)^2 \tag{20}$$

$$\frac{dC^{con}_{T,1}}{dY^{\omega}_{T,1}} = \frac{1+\kappa}{1+N-\kappa\varsigma} \qquad \frac{d^2C^{con}_{T,1}}{dY^{\omega}_{T,1}dN} = -\frac{1+\kappa}{(1+N-\kappa\varsigma)^2} \tag{21}$$

By comparing the results in the two lines, we find that constrained consumption is more sensitive to output shocks: marginal changes in income in such states (i) cannot be smoothed and are fully reflected in consumption in that period and (ii) trigger the financial accelerator, which reinforces the initial shock through a change in the valuation of non-tradable collateral and borrowing capacity. When borrowing constraints are loose, on the other hand, only a fraction of a marginal increase in income is consumed; the rest of it is saved so as to smooth consumption over time. The right column of the set of equations shows that increasing the fraction of local currency debt N reduces the sensitivity of consumption to output shocks by more in constrained states than in unconstrained states. We can summarize our results as follows.

Proposition 2 *Under binding borrowing constraints, consumption is more sensitive to shocks than when constraints are loose. Increasing the fraction of local currency debt reduces the sensitivity of consumption to shocks, and it does so more strongly when borrowing constraints are binding since local currency debt mitigates the financial accelerator mechanism. As a result, the volatility of consumption in the economy is decreasing in the fraction of local currency debt.*

So far we have described the agent's optimal period 1 and 2 allocations, given a realization $Y_{T,1}^{\omega}$ of the output shock and given a denomination (F_1, L_1) of his debt portfolio, as captured by the fraction N. We found that the agent's period 1 consumption is given by the two equations (17) and (19), and his borrowing in period 1 is given by (16) and (18) in unconstrained and constrained states. From the market clearing condition for non-tradables we trivially obtain $C_{N,t}^{\omega} = \bar{Y}_N$. Using the period 2 budget constraint (4) we find period 2 consumption of tradables $C_2^{\omega} = \bar{Y}_T - R^* F_2^{\omega}$.

3.3 Choice of Currency Denomination

We now turn to the agent's period 0 problem of how much local currency debt to take on. The relevant trade-off is captured by the first-order condition with respect to L_1 to the agent's Lagrangian (9). Denoting the utility function according to (13), we can express this condition as

$$E\left\{u'(C_{T,1}^{\omega})\left[R^* - R_{L,1}^{\omega}\right]\right\} = 0$$

We substitute the return on local currency $R_{L,1}^{\omega} = \frac{R^*}{1-\rho} \cdot \frac{p_{N,1}^{\omega}}{E[p_{N,1}^{\omega}]}$ from condition (7) to obtain

$$E\left\{u'(C_{T,1}^{\omega})\left[p_{N,1}^{\omega} - (1-\rho)E[p_{N,1}^{\omega}]\right]\right\} = 0$$

In equilibrium, the borrower's valuation of one unit of local currency $E[u'(C_{T,1}^{\omega}) \cdot p_{N,1}^{\omega}]$ equals the valuation of its certainty equivalent $E[u'(C_{T,1}^{\omega})] \cdot (1-\rho)E[p_{N,1}^{\omega}]$, i.e. of the expected value $E[p_{N,1}^{\omega}]$ discounted by lenders' risk premium ρ. The agent holds local currency debt up to the point where the additional insurance effect per unit of local currency debt equals the cost of obtaining the insurance, which is the risk premium. An alternative way of stating this equilibrium condition is

$$\mathrm{Cov}\left\{\frac{u'(C_{T,1}^{\omega})}{E[u'(C_{T,1}^{\omega})]}, \frac{p_{N,1}^{\omega}}{E[p_{N,1}^{\omega}]}\right\} = -\rho \tag{22}$$

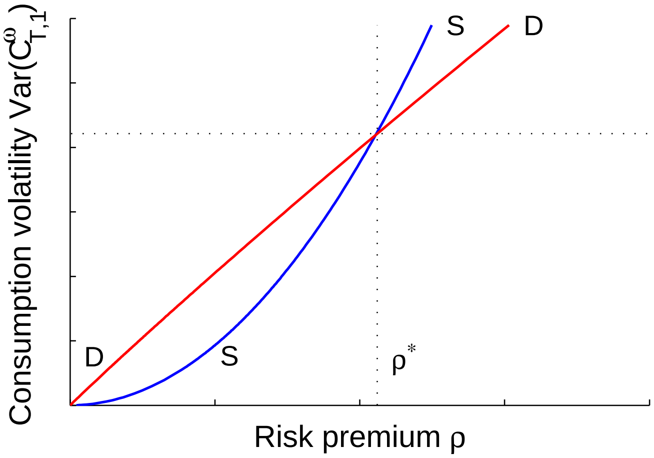

Figure 3: Equilibrium is determined by the intersection of lenders' supply locus SS and borrowers' demand locus DD for local currency debt

Since the real exchange rate (10) in our model is linear in tradable consumption, we substitute $p^{\omega}_{N,1}/E[p^{\omega}_{N,1}] = C^{\omega}_{T,1}/E[C^{\omega}_{T,1}]$ in the condition above. Furthermore, we approximate the agent's utility function by a suitable quadratic function so that his marginal utility is $u'(C_T) = \bar{C} - C_T$. This yields the equilibrium condition[15]

$$\text{Var}(C^{\omega}_{T,1}) = \rho E(C^{\omega}_{T,1}) E\left[u'(C^{\omega}_{T,1})\right] \tag{23}$$

The optimal variance of tradable consumption is directly proportional to the risk premium on local currency debt, i.e. to the cost of insuring against consumption volatility. In the extreme case of $\rho = 0$, domestic agents would like to insure perfectly against consumption fluctuations. In our model setup we assumed in accordance with empirical evidence that lenders charge a positive risk premium $\rho > 0$. This implies that domestic agents insure imperfectly and financial accelerator effects can occur. They opt for higher consumption volatility the higher the risk premium on local currency debt.

Given the equilibrium conditions for periods 1 and 2 that we stated at the end of subsection 3.2, we characterize equilibrium in period 0 by lenders' equilibrium condition (8) and the domestic agent's optimality condition (23), which are both implicit functions of the two variables N and ρ. Figure 3 plots the two conditions in a graph of consumption volatility $\text{Var}(C^{\omega}_{T,1})$ against the risk premium ρ, referring to them as lenders' supply locus SS of local currency debt and borrowers' demand locus DD. Both are increasing, as borrowers are willing to pay a higher risk premium and lenders demand a higher risk premium the more volatile consumption and the exchange rate. In the figure, lenders' SS locus (8) is a quadratic function and therefore convex, since the covariance term $\text{Cov}(C^{\omega}_{T,1}, M^{\omega}_1)$ is linear in the standard deviation of consumption

[15]The general result holds for all standard utility functions, i.e. the relationship between the covariance term in (22) and the variance of consumption is always monotonic, but not necessarily linear. It is common in the finance literature to approximate utility functions by quadratic functions in order to solve for portfolio shares.

$\text{Std}(C^{\omega}_{T,1})$, given the exogenous pricing kernel M^{ω}_1. Borrowers' DD locus (23) is close to linear.[16]

The fraction of local currency debt (as represented by N) increases as we move from the top right of the figure to the bottom left along the SS and DD loci, as a higher fraction of local currency debt reduces volatility in the economy. In the limit of $N \to \infty$, both loci end up in the origin. However, since we assumed that lenders are large and risk-averse, this degenerate outcome cannot be optimal for borrowers: they could obtain a first-order gain from lower borrowing costs by taking on an infinitesimal amount of risk at a second-order utility loss.

The shapes of the two optimality loci thus guarantee a unique non-degenerate equilibrium in period 0, as indicated in the figure. This pins down the equilibrium risk premium ρ^* and equilibrium consumption volatility, implicitly defining the equilibrium fraction of local currency debt N and the debt allocation in period 0 of (F_1, L_1). This fully describes the decentralized equilibrium in the emerging market economy.

4 Social Planner

The previous section solved the optimization problem of a decentralized agent who takes macroeconomic variables, and in particular exchange rates $p^{\omega}_{N,t}$, as given. A social planner, by contrast, internalizes the macroeconomic effects of her borrowing decisions. In particular, she internalizes that increased local currency borrowing makes the exchange rate less volatile, which reduces the incidence and severity of socially costly binding borrowing constraints. She also realizes that international lenders are indifferent between lending in dollars or local currency as long as the returns on both assets satisfy their pricing condition (6). Therefore we can equally think of the social planner as a benevolent policymaker in the emerging market economy or as a planner who maximizes the joint welfare of domestic and international agents.

The social planner maximizes the utility of the domestic agent (1), internalizing that her choices affect equilibrium exchange rates. Appendix A.2 spells out the Lagrangian of the associated optimization problem. We make the following assumption to keep our exposition simple:

Assumption 1 *The pricing kernel of international lenders and the real exchange rate in the domestic economy are linearly dependent,*

$$M^{\omega}_1 \cong p^{\omega}_{N,1}$$

Under this assumption, risk markets between the emerging market economy and international capital markets are effectively complete: the exchange rate always reflects the economy's consumption risk from equation (10) and the economy can achieve the same consumption allocations with dollar and local currency debt as in a market with a full

[16] A detailed derivation of the curvature of the DD locus shows that it is even mildly concave, since buying more insurance N also affects the expected level and the marginal utility of consumption. See (Korinek, 2008) for details.

set of Arrow securities (subject to the borrowing constraint). One possible interpretation of the assumption is that international lenders are emerging market specialists that cannot fully diversify their portfolio risk.[17]

The excessive dollar borrowing result of this paper arises independently of whether risk markets are complete or not. Introducing imperfections in risk markets into such an economy leads to additional distortions that are similar in nature to Stiglitz (1982) and that are not the central focus of this paper. We discuss these distortions in detail in appendix B and continue our analysis in the main text under the simplifying assumption 1 of complete risk markets.

The first-order condition on consumption $C^{\omega}_{T,1}$ states that the social planner equates the shadow value of period 1 wealth to the marginal utility of consumption of decentralized agents plus a term capturing that higher consumption relaxes borrowing constraints:

$$\mu^{\omega} = u'(C^{\omega}_{T,1}) + \lambda^{\omega}\kappa\varsigma \tag{24}$$

This second term on the right hand side distinguishes the social planner's solution from the decentralized equilibrium and is responsible for the central externality result of this paper: the social planner internalizes that raising tradable consumption by one unit appreciates the exchange rate by ς, increases the dollar value of domestic collateral and alleviates the borrowing constraint by $\kappa\varsigma$. The utility value of this loosening of the constraint is $\lambda^{\omega}\kappa\varsigma$ and is positive whenever the borrowing constraint is binding so that $\lambda^{\omega} > 0$.

4.1 Euler Equation

Substituting expression (24) into the first-order condition on period 2 borrowing F_2 of the social planner's problem and making the standard assumption that $\beta R^* = 1$, we obtain the social planner's Euler equation:

$$u'(C^{\omega}_{T,2}) + \lambda^{\omega}(1 - \kappa\varsigma) = u'(C^{\omega}_{T,1}) \tag{25}$$

Since the social planner's marginal valuation of period 1 consumption μ^{ω} is different from the decentralized agent's valuation $u'(C^{\omega}_{T,1})$, the social planner also faces a different intertemporal tradeoff than what is captured by the decentralized Euler equation (15). In the following, we first describe the case of slack borrowing constraints; then we discuss the externality term that arises if borrowing constraints are binding.

Slack Borrowing Constraints

If borrowing constraints are slack, then by definition $\lambda^{\omega} = 0\ \forall\omega$ and the λ^{ω}-term drops from the social planner's Euler equation. As a result, both the decentralized agent's Euler equation (15) and the social planner's equation (25) imply $u'(C^{\omega}_{T,1}) = u'(C^{\omega}_{T,2})$, i.e. consumption is smoothed perfectly across periods 1 and 2.

[17] The assumption also holds naturally in analytical models in which there are only two states of nature since two bonds automatically span the state space in such models.

Binding Borrowing Constraints

Let us next look at states where borrowing constraints are binding, i.e. the multiplier λ^ω on the borrowing constraint is positive. In such a situation, both decentralized agents and the social planner borrow the maximum amount possible given the constraint (18), i.e. $F_2^{\omega,\text{con}} = \kappa(Y_{T,1}^\omega + \varsigma C_{T,1}^\omega)$, and for given N they choose identical consumption allocations.

However, they differ in how much they value the cost of binding borrowing constraints. By comparing the decentralized Euler equation (15) and the social planner's equation (25), we can see that the latter multiplies the shadow value λ^ω by the factor $(1-\kappa\varsigma) < 1$. For a given allocation of $(C_{T,1}^\omega, C_{T,2}^\omega)$ with binding borrowing constraints, the social planner therefore has a higher shadow price λ^ω. He puts a higher value on relaxing the constraint since he recognizes the resulting multiplier effect. A relaxation of the constraint by one unit enables domestic agents to increase first-period consumption $C_{T,1}^\omega$ by the same amount, which in turn appreciates the exchange rate by ς, raises the value of non-tradable collateral, loosens the borrowing constraint by $\kappa\varsigma$, causes a further increase in consumption, and so forth. Ultimately, relaxing the borrowing constraint by one unit leads to an increase in consumption by $\frac{1}{1+N-\kappa\varsigma}$, as can easily be seen from equation (19). We will show in the following subsection that this different value attached to binding borrowing constraints induces the social planner to insure more, i.e. to borrow more in local currency than the domestic agent.

4.2 Optimal Debt Denomination

Decentralized agents trade off the benefits and costs of insurance against consumption risk in choosing the composition of their debt portfolio. The social planner, on the other hand, also considers the impact of local currency debt on the incidence of collateral constraints.

The social planner's first-order condition on (30) with respect to the fraction of local currency debt N is $E\left\{\mu^\omega\left[C_{T,1}^\omega - (1-\rho)E(C_{T,1}^\omega)\right]\right\} = 0$. He uses the social shadow value μ^ω to value the payment streams of local currency and dollar debt instead of the private benefit $u'(C_{T,1}^\omega)$. Substituting for this shadow value from expression (24) and using the definition of the risk premium in (12) we obtain

$$\text{Cov}(u'(C_{T,1}^\omega), C_{T,1}^\omega) = -\rho E[C_{T,1}^\omega]E[u'(C_{T,1}^\omega)] - \kappa\varsigma E\left[\lambda^\omega\left(C_{T,1}^\omega - (1-\rho)E[C_{T,1}^\omega]\right)\right]$$

or, approximating the utility function with a quadratic function,

$$\text{Var}(C_{T,1}^\omega) = (\rho-\theta)E[C_{T,1}^\omega]E[u'(C_{T,1}^\omega)] \tag{26}$$

$$\text{where we define}\quad \theta = -\kappa\varsigma \cdot E\left[\frac{\lambda^\omega}{E[u'(C_{T,1}^\omega)]}\cdot\frac{C_{T,1}^\omega - (1-\rho)E[C_{T,1}^\omega]}{E[C_{T,1}^\omega]}\right] \tag{27}$$

The social planner's optimality condition differs from the decentralized agent's condition (23) by the externality term θ, which captures the effects of local currency debt on borrowing constraints and is typically positive. A detailed discussion of the sign of θ follows below.

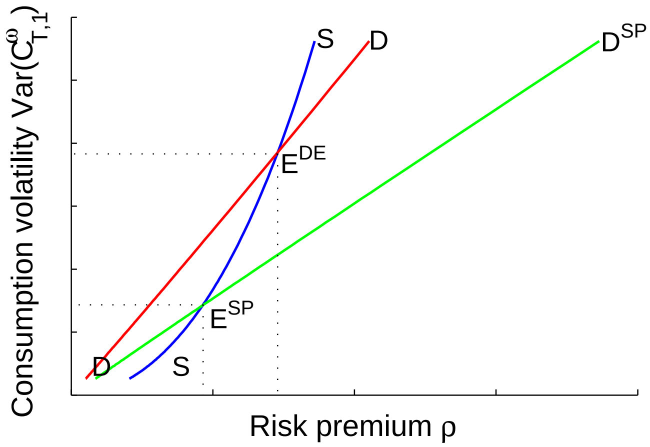

Figure 4: Social planner's optimum E^{SP} versus decentralized equilibrium E^{DE}

The decentralized agent takes the tightness of borrowing constraints in every state of nature as exogenous, since it depends on a macroeconomic price, the exchange rate. By contrast, the social planner internalizes that his choices affect the exchange rate. For positive θ, we can see from equation (26) that the social planner chooses her debt portfolio such that the economy exhibits less consumption volatility. As we discussed in the previous section, this can be obtained by taking on a higher fraction of local currency debt. The following proposition summarizes our main result:

Proposition 3 *An economy with a positive externality term $\theta > 0$ exhibits excessive dollar borrowing. The social planner in such an economy contracts a higher fraction of local currency debt than decentralized agents. As a result, the economy is characterized by lower consumption volatility, lower exchange rate volatility, a reduction in the risk premium on local currency, and higher welfare.*

Graphically, a positive externality term θ implies that the social planner's optimality locus for local currency debt DD^{SP} is to the right of decentralized agents' optimality locus DD in figure 4: for a given level of consumption volatility, the social planner would be willing to pay a higher risk premium. The figure shows that as a result, the social planner's equilibrium exhibits lower consumption volatility and a lower risk premium.

The term $C^{\omega}_{T,1} - (1-\rho)E[C^{\omega}_{T,1}]$ in equation (27) reflects the marginal effects of local currency debt on aggregate demand. It can be separated into two parts: (i) The *insurance effect* of local currency debt is to swap a fixed repayment against a contingent repayment of identical expected value, providing a counter-cyclical insurance payoff of $E[C^{\omega}_{T,1}] - C^{\omega}_{T,1}$. (ii) The *risk premium* on local currency debt requires an uncontingent payment $\rho E[C^{\omega}_{T,1}]$ to international lenders to compensate them for taking on the risk.

Condition 1 *The externality term θ is positive and the decentralized equilibrium exhibits excessive dollar borrowing if and only if the insurance effect of local currency debt* *on borrowing constraints outweighs the risk premium effect on borrowing constraints, i.e. if*

$$E\left[\lambda^\omega\left(E[C^\omega_{T,1}] - C^\omega_{T,1}\right)\right] = -\mathrm{Cov}\left(\lambda^\omega, C^\omega_{T,1}\right) > \rho E[C^\omega_{T,1}]E[\lambda^\omega]$$

The *insurance effect* on the left-hand side captures the marginal contribution of the insurance aspect of local currency debt to alleviating borrowing constraints. Borrowing constraints are typically binding, i.e. $\lambda^\omega > 0$ in low states of nature where consumption is below average and insurance yields positive payoffs, i.e. $C^\omega_{T,1} < E[C^\omega_{T,1}]$. By implication the product $\lambda^\omega\left(E[C^\omega_{T,1}] - C^\omega_{T,1}\right)$ is positive in such states. This captures that local currency debt provides insurance in low states, which mitigates the depreciations in the exchange rate and raises the value of non-tradable collateral, thereby loosening borrowing constraints and raising welfare. On the other hand, in high and unconstrained states of nature the product is always zero, since $\lambda^\omega = 0$. The impact of borrowing constraints is therefore asymmetric: loosening binding constraints in low states is beneficial, while tightening loose constraints in high states is costless.

More generally, λ^ω is always decreasing in the shock $Y^\omega_{T,1}$ whereas $C^\omega_{T,1}$ is increasing in $Y^\omega_{T,1}$. Therefore the insurance effect on borrowing constraints is always positive: $E\left[\lambda^\omega\left(E[C^\omega_{T,1}] - C^\omega_{T,1}\right)\right] = -\mathrm{Cov}(\lambda^\omega, C^\omega_{T,1}) > 0$.

The *risk premium effect* on the right-hand side of condition 1 represents how the payment of the risk premium affects borrowing constraints. The payment lowers consumption in all states by an identical amount $\rho E[C^\omega_{T,1}]$. In states where borrowing constraints are binding, this reduction in consumption and the resulting exchange rate depreciation tighten the constraint and reduce welfare. The risk premium effect therefore always has the effect of tightening borrowing constraints.

By comparing the two effects in a large number of different settings, it can be seen that the insurance effect generally outweighs the risk premium effect by a large margin.[18] Below we report the results of three particular settings to illustrate the positive sign of the externality term θ under common choices of parameter values:

Example 1 In an economy where $\hat{C}_{T,1} < (1-\rho)E[C^\omega_{T,1}]$, the payoffs to insurance in constrained states are always positive. Therefore the product in the externality term (27) is either negative or zero for any state $\omega \in \Omega$, and by implication $\theta > 0$. The decentralized equilibrium in such an economy is always characterized by excessive dollar borrowing.

[18] In our numerical simulations, the only way to obtain a negative externality term $\theta < 0$ was to make two strong assumptions: (1) Risk aversion among international lenders is extremely high so that the risk premium ρ reaches high double digit percentages. (2) Consumption between periods 1 and 2 increases by a large margin, but cannot be smoothed because of extremely tight borrowing constraints, and the marginal utility of consumption correspondingly falls by a high double digit percentage between the two periods. As a result $E[\lambda^\omega]$ is large in comparison to $-\mathrm{Cov}(\lambda^\omega, C^\omega_{T,1})$. In combination the two assumptions together can make the risk premium effect larger than the insurance effect on borrowing constraints: the loss in consumption from the high payments on risk compensation $\rho E[C^\omega_{T,1}]$ depreciates the exchange rate so much that borrowing constraints in the economy are on average tightened when more local currency debt is taken on. The social planner would reduce the fraction of local currency debt in order to save on the risk premium and raise average consumption, which would on average appreciate the exchange rate and loosen borrowing constraints, enhancing social welfare.

σ_Y	σ	β	κ	$\bar{I}$	W_0	N	ρ	θ
.04	.40	.96	.33	.25	-.54	.10	3.00%	1.25%

Table 1: Structural parameters, calibrated values, and resulting externality in example 3

Example 2 In an economy with only two states $\omega \in \{L, H\}$, any equilibrium allocation satisfies that consumption in the low state $C_{T,1}^L < (1-\rho)E[C_{T,1}^\omega]$. Otherwise, lowering the amount of local currency debt would increase consumption in both states of the world and make agents unambiguously better off, which would violate the assumption that agents maximize their utility. If agents are only constrained in the low state, then increasing the amount of local currency debt would unambiguously alleviate these borrowing constraints. Consequently, condition (27) is always positive and decentralized agents in this economy borrow excessively in dollars.

Example 3 We calibrate our model to match the situation of a typical small open emerging market economy (see table 1).[19] We normalize the economy's output of T and N to 1, and we assume that the output shock $Y_{T,1}^\omega$ is normally distributed around this value with a standard deviation of $\sigma_Y = 4\%$.[20] The share of tradables in the domestic agent's utility function (1) is $\sigma = 0.40$, which implies that the value of non-tradable to tradable consumption is $\frac{p_{N,1}^\omega \bar{Y}_N}{C_{T,1}^\omega} = \varsigma = 1.5$. Investment of tradables and initial wealth (which both perform the function of creating a need for borrowing in our stylized model) are set to $\bar{I} = 25\%$ and $W_0 = -54\%$ of tradable output, and we assume the discount rate of domestic agents and the risk-free gross interest rate of international lenders to be $\beta = .96$ and $R^* = 1/\beta$. Following Mendoza (2005), we set the income multiplier κ in the borrowing constraint to 0.33.

We calibrate the risk aversion of domestic agents and of international lenders respectively so as to yield an equilibrium fraction of local currency debt of $N = 10\%$ of expected tradable consumption, which is consistent with data reported in the BIS Quarterly Review for typical emerging markets, at a local currency interest rate premium of $\rho = 3\%$. In doing so we approximate the domestic agent's utility function by a quadratic function, as in expressions (23) and (26), and we calibrate the international lenders' pricing kernel M_1^ω to be perfectly negatively correlated with the output shock $Y_{T,1}^\omega$. In the resulting decentralized equilibrium, borrowing constraints are binding with a probability of 14.4%, which is consistent with the economy experiencing a sudden stop roughly once every seven years. Our simulations yield that the externality associated with decentralized agents' dollar borrowing in such an economy, i.e. the social cost of dollar debt that is not internalized by decentralized agents, is 1.25 cent per dollar of debt. The excessive dollar borrowing result, i.e. the positive sign of θ, continues to hold if we vary the parameters of table 1 within a wide range of values.

[19]The goal of this exercise is to illustrate that the described externality can be quantitatively sizeable even in the simple model of this paper.

[20]This corresponds e.g. to the typical yearly standard deviation of output growth in East Asian economies.

5 Policy Implications

5.1 First-Best Policy Measures

The externality that we analyzed in this paper is rooted in the financial accelerator effect that arises from the interaction of foreign currency debts with borrowing constraints. Naturally, the first-best policy solution would be to address the capital market imperfections that underlie these borrowing constraints. Examples for such policies include improving the enforcement of creditor rights, streamlining bankruptcy proceedings etc.

Another key factor that is necessary for the externality result is aversion to emerging market risk on the part of international lenders. Without the risk premium on local currency debt, domestic borrowers would have no incentive to resort to dollar debt and would not impose externalities. A number of researchers have put forward proposals to deepen international markets in emerging market currencies so as to lower their cost of borrowing in local currency debt (see Dodd and Spiegel, 2005; Eichengreen and Hausmann, 2005). This would reduce the externality to dollar debt. However, in the short to medium term, policymakers in emerging markets have to take many of the features of their economies and of international capital markets as given.

5.2 Second-Best Policy Measures

Recognizing the limitations of first-best policy measures, researchers have suggested a number of second-best measures.

Exchange Rate Pegs

A widespread policy in emerging markets that have sought to avoid the social costs of contractionary depreciations has been to stabilize or peg exchange rates (see e.g. Calvo and Reinhart, 2002). If an exchange rate peg is perfectly credible, local currency and foreign currency debt are equivalent. As a result, there would be no more externality associated with borrowing in foreign currency.

In practice exchange rate pegs in emerging markets are almost never perfectly credible: pegs tend to fall precisely in those states of nature with the worst macroeconomic realizations, giving rise to strong financial accelerator effects. Our externality result still holds in the case of an imperfectly credible peg that only collapses during crises: domestic borrowers want to save on lenders' risk premium and engage in dollar borrowing, not recognizing that this will adversely affect the tightness of constraints in crisis states.

In the analytical framework of this paper, exchange rate pegs could be modeled e.g. as a buffer of tradable goods ('reserves') to stabilize tradable consumption in the economy. As captured by equation (10), this would fix the real exchange rate and interrupt financial accelerator effects. The recent accumulation of reserves in emerging markets, in particular in Asia (see e.g. Aizenman and Marion, 2003), can thus be viewed as a policy measure to reduce the externalities associated with dollar borrowing. Jeanne and Rancière (2006) develop a quantitative framework to calculate the optimal level of

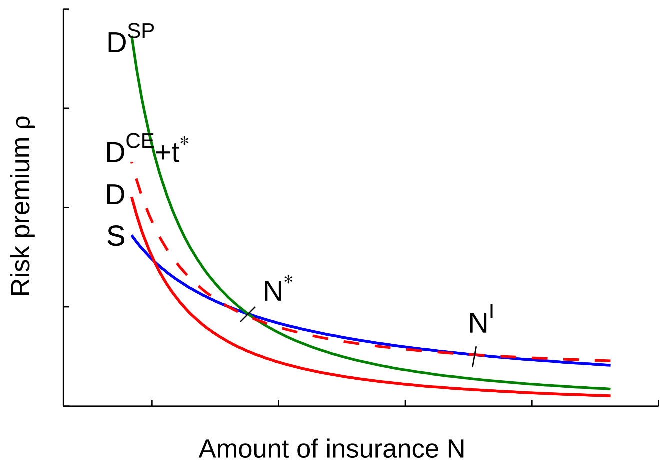

Figure 5: Implementation of the social optimum N^* using a linear tax t^*

reserves for emerging market economies in order to smooth domestic absorption during crises.

Optimal Taxation

We showed above in section 4 that the socially optimal level of dollar debt is in general less than the amount of debt that individual borrowers contract in the decentralized equilibrium. It follows naturally that the social planner could improve welfare by taxing dollar debt, which would make domestic agents internalize the externality associated with dollar borrowing.

The optimal tax raises the cost of dollar debt to the point that the decentralized agent's privately optimal choice of dollar versus local currency debt implements the social planner's optimum.[21] We use the superscripts SP to denote the variables in that equilibrium. The premium on local currency debt ρ^{SP} in the social planner's optimum reflects the relative social benefits of local currency over dollar debt, which consist of the social benefit of relaxing economy-wide collateral constraints, captured by the externality term θ^{SP} as defined in (27), plus the private insurance benefits, captured by the remainder $\rho^{SP} - \theta^{SP}$. An optimal tax raises the relative cost of dollar debt by θ^{SP} so that decentralized agents face an effective risk premium of $\rho^{SP} - \theta^{SP}$ on local currency debt and their privately optimal risk-return trade-off yields the social optimum. By comparing the social planner's equilibrium condition (26) with the decentralized agent's optimality condition (23) it can be seen that a tax satisfying this condition can indeed implement the social optimum. We analyze two specific forms of taxation in detail.

Linear Tax on Dollar Debt

A linear (or specific) tax t on dollar debt obliges a borrower to pay \$$t$ in taxes for every dollar in debt taken on, irrespective of the interest rates on dollar or local currency debt. In order to reduce the risk premium on local currency debt by θ^{SP}, a policymaker has to raise the cost of dollar debt by a linear t^* that satisfies

$$[1-(\rho^{SP}-\theta^{SP})]E[R^{\omega}_{L,1}] = R^* + t^* \qquad \text{or} \qquad t^* = \theta^{SP} E[R^{\omega}_{L,1}] \tag{28}$$

In equilibrium, this optimal linear tax raises the cost of dollar debt to the point that the return differential to local currency debt reflects the private insurance benefit of local currency debt, i.e. the social benefit ρ^{SP} minus the externality θ^{SP}. A graphical example is provided in figure 5, where the decentralized demand D, the decentralized demand-cum-tax $D^{CE}+t^*$ and the social planner's demand for local currency as well as international lenders' supply of local currency debt are plotted against the risk premium. An appropriate linear tax t^* can implement the social optimum N^*.

In example 3 of the previous section, we noted that the risk premium on local currency debt and the externality on dollar debt in the decentralized equilibrium were $\rho^{DE} = 3\%$ and $\theta^{DE} = 1.25\%$ respectively. By contrast, the social planner's equilibrium is characterized by more local currency debt, less consumption volatility, a lower risk premium $\rho^{SP} = 1.74\%$ and a smaller externality $\theta^{SP} = 0.61\%$. Using equation (28) we can calculate the optimal linear tax on dollar debt as $t^* = 0.66\%$.

The optimal tax rate is considerably smaller than the externality in the decentralized equilibrium, since taxing dollar debt induces agents to shift their debt holdings towards local currency debt and, as a result, the economy becomes less volatile, implying a smaller risk premium and a smaller externality. In the given example, the tax t^* increases the amount of local currency debt in the economy fourfold.

The reason why a relatively small tax on dollar debt can induce such a large change in the behavior of domestic agents is that local currency and dollar debt are close substitutes in normal times. Hence a small change in the relative price of the two can entail a large reallocation in the debt portfolio of borrowers towards local currency debt.

However, a specific tax t^* has an important disadvantage: it leads to multiple equilibria. Aside from the social optimum, it can also implement an inefficient equilibrium with excessive local currency debt (in figure 5 denoted as N^I). In that equilibrium, volatility in the economy is low because of the high amount of domestic currency debt; hence the externality θ is considerably smaller than it would be in the social optimum. But since the tax t^* is fixed and does not adjust to the smaller externality, it induces borrowers to take on an inefficiently large amount of local currency debt.

Proportional Tax on Dollar Debt

A more effective policy measure that uniquely implement the social optimum is a tax on dollar debt that amounts to a fraction τ of the risk premium ρ on local currency

[21] Standard results on tax incidence imply that economically, the tax is always borne by domestic borrowers, since international lenders are large and have a horizontal supply curve. However, in practice, it is easier to collect taxes from lenders when the relevant capital flows enter the country through international payment systems.

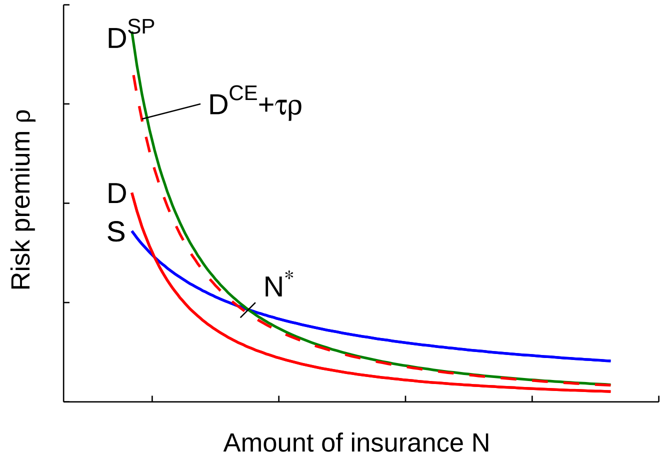

Figure 6: Unique implementation of the social optimum using a tax τ proportional to the risk premium on local currency debt ρ

debt. The optimal magnitude τ of such a tax can be determined by the condition

$$[1-(\rho^{SP}-\theta^{SP})]E[R^{\omega}_{L,1}] = R^* + \tau\rho^{SP} \quad \text{or} \quad \tau = \frac{\theta^{SP}}{\rho^{SP}}E[R^{\omega}_{L,1}] = \frac{\theta^{SP}\cdot R^*}{\rho^{SP}(1-\rho^{SP})} \tag{29}$$

In example 3 above, the optimal $\tau = 37\%$. Figure 6 shows that such a proportional tax accounts for the fact that the size of the externality varies as the amount of local currency debt in the economy changes. As a result the demand curve of decentralized agents that are subject to taxation $D^{CE}+\tau\rho$ is very close to the social planner's demand curve D^{SP} and the social optimum can be uniquely implemented.

Risk premia are not directly observable in financial markets. However, our proposal of a tax proportional to the risk premium on local currency can be implemented by imposing a particular form of reserve requirement on lenders that grant dollar loans: every lender has to hold τ dollars in a reserve account with the central bank per dollar lent to domestic agents; the reserve holdings would be denominated in local currency (possibly inflation-indexed), but would be remunerated only at the interest rate on dollar loans. As a result, the expected loss in interest from such a reserve requirement would equal the risk premium between dollar and local currency debt.[22]

Robustness of Tax Measures

A further advantage of proportional taxation (or, equivalently, of a reserve requirement denominated in local currency) is its robustness to changes in risk aversion among international lenders. A considerable part of the risk premia faced by emerging markets are due to external factors such as global risk aversion (see e.g. Longstaff et al., 2007), which often fluctuates at high frequencies.

[22]Requiring unremunerated reserves in dollars would be isomorphic to the linear tax that we discussed earlier and would be subject to the same limitations. A linear tax t^*, for example, could equally be implemented as a reserve requirement of $\frac{t^*}{R^*-1}$ per dollar lent. A similar approach was used by Chile to regulate short-term capital flows (see e.g. Gallego et al., 2002).

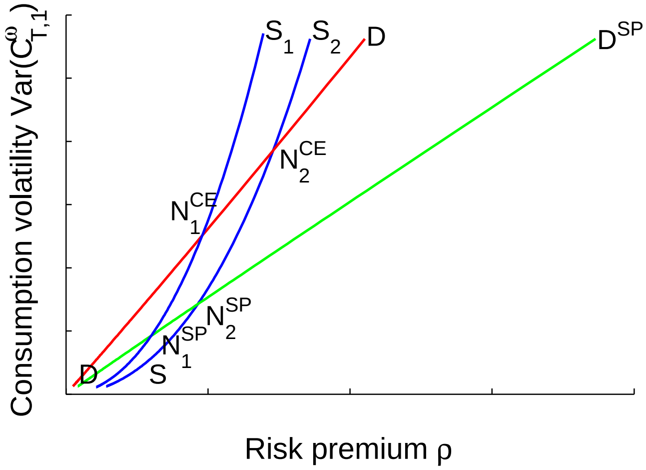

Figure 7: Multiplier effect to changes in the risk aversion of international lenders

Figure 7 illustrates the effect of e.g. an increase in the risk aversion of international lenders, represented by a mean-preserving spread in their pricing kernel M_1^ω (Rothschild and Stiglitz, 1970): their optimality locus shifts from SS_1 to the right to SS_2: for a given level of macroeconomic volatility, they demand a higher risk premium on local currency. As depicted in the figure, this entails a multiplier mechanism: given the higher risk premium, domestic agents find it optimal to borrow less in local currency and more in dollars, which raises macroeconomic volatility and the risk premium even further. Small changes in the risk aversion of international lenders can thus lead to large changes in the equilibrium amount of dollar debt and in equilibrium risk premia.[23]

An increase in lenders' risk aversion also raises the size of the externality θ, as shown in the figure by the increasing horizontal difference between the dencentralized demand locus DD and the social demand locus DD^{SP} for rising risk premia. A planner who imposes a linear tax would have to continuously adjust the tax rate in response to changes in international risk aversion in order to continually implement the social optimum. On the other hand, for a planner who uses a proportional tax τ, changes in the risk premium automatically lead to changes in the effective tax burden on dollar borrowers; therefore the proportional tax rate can be kept constant.

While we have formulated the second-best policy measures in this section as 'taxes,' note that there are a number of other policy measures that have similar effects to outright taxes on dollar debt. These include domestic banking regulations against dollar debt, capital adequacy rules for international lenders that discriminate against dollar debts, differential tax deductability or differential bankruptcy regulations. The common element of these measures is that they differentially raise the cost of denominating debt contracts in dollars as opposed to local currency.

Forbes (2005), among others, discusses a number of arguments against capital controls. First and foremost, she argues that capital controls increase the cost of finance for firms. However, if firms undervalue the cost of taking on risky dollar debt because of an

[23]See Korinek (2008) for a detailed analysis of this point.

externality, then this is precisely the desired outcome: the tax makes them internalize this factor and increases welfare. Secondly, a drawback of capital controls is that they give rise to various kinds of distorted behavior, e.g. attempts to evade the controls. This is the case with any form of government regulation, and it entails that governments have to design their regulations and monitor their implementation carefully.[24] For example, regulations in debt markets have to be accompanied by corresponding regulations in derivatives markets to avoid evasion. Moreover, even if capital controls introduce some distortions and give rise to some evasion, they will achieve their desired effect of reducing a country's aggregate exposure to dollar debts as long as evasion is not costless.

5.3 Dollar Debts in the Tradable Sector

Crises and the ensuing sharp depreciations in exchange rates often lead to wide-spread bankruptcies among firms with currency mis-matches on their balance sheets. As a result, a common policy prescription for emerging markets has been to require borrowers to match the currency denomination of their debts and revenues (see e.g. Goldstein and Turner, 2004). While it is certainly better to allocate a given amount of dollar debt in an emerging market economy to firms in the tradable goods sector than to the non-tradable sector, this emphasis on mis-matches at a microeconomic level leaves out an important macroeconomic dimension.

Even in an economy where firms have matched the currency denomination of revenues and liabilities, dollar debt still makes the macroeconomy as a whole, and the country's exchange rate in particular, more volatile. Decentralized agents do not internalize this and therefore impose an externality on other agents who own non-tradable collateral. Specifically, if tradable firms hold local currency debt as opposed to dollar debt in an economy that experiences a negative shock, the impact of the shock on aggregate demand will be mitigated. As a result, the exchange rate will depreciate less and borrowing constraints on non-tradable firms will be loosened – an implication that decentralized agents do not internalize.

As in our benchmark model, the private incentives to take on insurance in such an economy are lower than the social incentives. This illustrates that it is desirable to impose restrictions on the use of dollar debt at the macroeconomic level, even if regulations that restrict risk-taking at the microeconomic level are already in place.

5.4 Optimal Indexation of Debt Instruments

Our findings on the private and social insurance benefits of different forms of debt bring up a more general question. Contingent debt contracts generally allow for greater international risk-sharing; therefore policymakers have long advocated the introduction of debt instruments that are indexed to pro-cyclical real variables or prices so as to provide for a greater scope of insurance (see e.g. Borensztein et al., 2004). Because of the network externalities that arise from high market liquidity, it is argued that a

[24] For example, prudential regulations on banks distort the behavior of banks in industrialized countries, yet the economics profession does not typically regard this as a reason to abolish them.

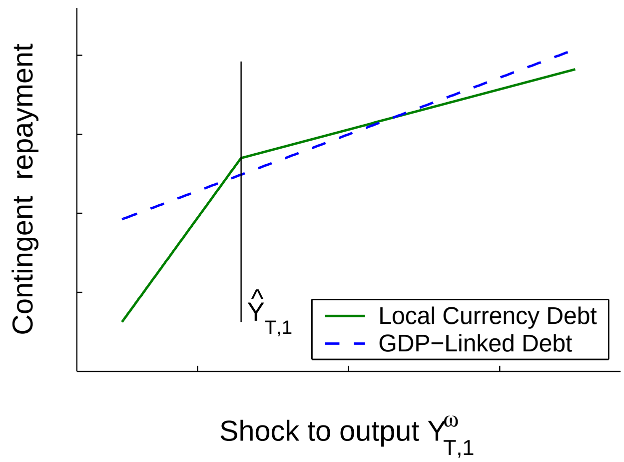

Figure 8: Insurance characteristics of local currency versus GDP-linked dollar debt

developing country that wants to create a new debt instrument should focus its efforts on the creation of one new asset class at a time. What variable should a new contingent debt contract best be indexed to? While a general analysis of this question is beyond the scope of this paper, let us briefly discuss the relative insurance benefits of local currency debt and GDP-indexed debt, an instrument that was advocated e.g. by Griffith-Jones and Sharma (2006).

In our framework, we modeled local currency debt as linked to the price of non-tradables p_N, i.e. the real exchange rate, which is pro-cyclical. GDP-linked debt is indexed to the country's productivity shock $Y^{\omega}_{T,1}$ itself. Both debt instruments therefore entail high repayments in good states of nature and low repayments in bad states of nature. However, as illustrated in figure 8, the response of the exchange rate differs significantly between normal times and crisis times. In normal times, decentralized agents smooth consumption over time, implying relatively stable exchange rates. When borrowing constraints are binding, the financial accelerator is triggered. The fall in domestic agents' borrowing capacity leads to a current account reversal, which causes both consumption and the exchange rate to fall more strongly than output.

Since individuals care about smooth consumption not smooth output, this suggests that local currency debt is a superior risk-sharing instrument to GDP-linked debt. The countries affected by the East Asian crisis present a clear case in point: even though the variance of quarterly changes in their real exchange rates was smaller then the variance in growth over the past quarter century, the depreciation in their real exchange rates during the Asian financial crisis was many times stronger than the fall in GDP.[25] Local currency debt would thus have provided much better insurance against the East Asian crisis than GDP-linked debt.

The strong response of the real exchange rate to shocks in constrained states also has an important implication for the efficiency of the decentralized equilibrium under GDP-linked debt versus local currency debt: GDP-linked debt mandates higher repayments in constrained states than local currency debt, and therefore it insures relatively

[25]Data from International Financial Statistics, 1982 – 2007, and author's calculations.

less against crises. Decentralized agents do not internalize the effects of insurance instruments on the incidence of borrowing constraints. They will under-insure even more when the contingent debt instrument that they have access to is GDP-linked debt than when it is local currency debt. This suggests that from an insurance perspective, it is better for emerging market governments to promote the development of markets for local currency debt rather than to create markets for GDP-linked debt.

6 Conclusions

This paper analyzed the optimality of decentralized borrowing decisions in a typical emerging market economy. We found that if the economy is prone to collateral-dependent borrowing constraints, decentralized agents engage in socially excessive dollar borrowing because they fail to internalize that dollar debt reinforces the financial accelerator mechanism that is triggered when borrowing constraints are binding. Dollar debt implies that aggregate demand declines more strongly and exchange rates depreciate further in low states of nature. In the absence of market imperfections, this would be a purely pecuniary externality. However, in emerging markets strong depreciations in the exchange rate have contractionary effects because they deteriorate balance sheets and tighten borrowing constraints, as we illustrated in this paper. As a result, the exchange rate volatility created by dollar debt entails a real externality. Small decentralized agents who take exchange rates as given do not internalize their contribution to the contractionary effects of exchange rate depreciations. Therefore they take on too much dollar debt.

We have discussed a number of potential policy remedies to correct the distortion: While a linear tax on dollar debt can result in multiple equilibria, we showed that a tax on dollar debt that is proportional to the risk premium on local currency debt can uniquely implement the social optimum and is robust to fluctuations in the risk aversion of international lenders. Such a tax can be implemented through a reserve requirement that is held in local currency and remunerated below market rates. Since the externality that we identify is of a macroeconomic nature, we find that a focus on avoiding microeconomic mismatches in the currency composition of a firm's revenues and liabilities is insufficient in restoring the social optimum. Instead, it is desirable to regulate foreign currency denominated debts even among firms in the tradable sector. Furthermore, we showed that local currency debt is a superior insurance instrument to other indexed debt contracts such as GDP-linked dollar debt. The reason is that consumption and exchange rates typically fall more strongly than GDP during crisis periods because of the current account reversals associated with financial crises.

On a methodological level, our contribution was to show that the financial accelerator mechanisms that have frequently been used to describe financial crises in the literature on emerging market finance (see e.g. Krugman, 1999; Mendoza, 2006) can create an externality that introduces a bias towards excessive dollar borrowing. The mechanism of such financial accelerator effects is a feedback loop from depreciating exchange rates to falling aggregate demand (in our model because of balance sheet effects) and from falling aggregate demand to further depreciations in the exchange rate (in this paper standard demand effects induce a real depreciation). Decentralized agents have rational expectations regarding the exchange rate and internalize the first part of this feedback loop, but since they are atomistic they do not internalize the second part, which is responsible for the externality.

The existing literature on financial crises has taken the widespread use of dollar debt in emerging markets as given and has shown that dollar debts play an essential role in the propagation of crises by contributing to the financial accelerator. We complement this literature by showing that the externalities created by the financial accelerator are an important reason why decentralized agents hold such large amounts of dollar denominated debt.

While the analysis in this paper has focused on the choice of emerging market borrowers between dollar and local currency denominated debt, our results point towards two broaders sets of issues: First, the externalities created by financial accelerator mechanisms have more general implications for other forms of capital flows as well as for the level and form of investment in emerging market economies. Secondly, financial accelerator effects also play an important role in the closed economy macroeconomics literature (see e.g. Kiyotaki and Moore, 1997; Bernanke et al., 1999). Our preliminary investigations suggest that similar externalities arise in closed economies when financial accelerator effects arise. These issues are the subject of our ongoing research.

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A Mathematical Appendix

A.1 Derivation of $\hat{Y}_{T,1}$

At the cutoff $\hat{Y}_{T,1}$, the constrained and the unconstrained levels of consumption $C_{T,1}^{\text{con}}$ and $C_{T,1}^{\text{unc}}$ are equal so that the constraint is marginally binding. We find $\hat{Y}_{T,1}$ as the value of $Y_{T,1}^{\omega}$ for which the two expressions (17) and (19) are equal.

$$[1+R^*(1+N)][(1+\kappa)\hat{Y}_{T,1}-(1+R^*)\bar{I}+R^*W_0+(1-\rho)NE(C_{T,1})] = \\ [1+N-\kappa\varsigma][\bar{Y}_T+R^*\hat{Y}_{T,1}-R^*(1+R^*)\bar{I}+(R^*)^2W_0+(1-\rho)NR^*E(C_{T,1})]$$

This can be solved for

$$\hat{Y}_{T,1} = \frac{(1+\kappa\varsigma R^*)\left[(1+R^*)\bar{I}-R^*W_0-(1-\rho)NE[C_{T,1}^{\omega}]\right]+\bar{Y}_T\,(1+N-\kappa\varsigma)}{1+\kappa\left[1+R^*\left(1+N-\varsigma\right)\right]}$$

A.2 Social Planner's Optimization Problem

We can formulate the Lagrangian of the social planner's optimization problem as

$$\mathcal{L}^{SP} = E\Big\{u\left(C_{T,1}^{\omega}\right)+\beta u\left(\bar{Y}_T-R^*F_2^{\omega}\right)-\lambda^{\omega}\left[F_2^{\omega}-\kappa\left(Y_{T,1}^{\omega}+\varsigma C_{T,1}^{\omega}\right)\right] \\ -\mu^{\omega}\left[C_{T,1}^{\omega}-Y_{T,1}^{\omega}+(1+R^*)\bar{I}-R^*W_0+N\left(C_{T,1}^{\omega}-(1-\rho)EC_{T,1}\right)-F_2^{\omega}\right] \\ -\nu\left[\rho EC_{T,1}+(C_{T,1}^{\omega}-EC_{T,1})(R^*M_1^{\omega}-1)\right]-\eta\left[EC_{T,1}-C_{T,1}^{\omega}\right]\Big\} \quad (30)$$

where λ^{ω} is the multiplier on the borrowing constraint in state ω, μ^{ω} is the shadow value of increasing period-1 consumption $C_{T,1}^{\omega}$, and ν and η are the multipliers on the constraint (12) determining international lenders' risk premium and on the auxiliary equation $EC_{T,1}=E[C_{T,1}^{\omega}]$.

Note that the covariance term in the constraint determining lenders' risk premium $\rho E[C_{T,1}^{\omega}] = R^*\text{Cov}(C_{T,1}^{\omega}, M_1^{\omega}) = E\left[(C_{T,1}^{\omega}-E[C_{T,1}^{\omega}])(R^*M_1^{\omega}-1)\right]$ contains two nested expectations which need to be calculated using two different integrating variables. We address this problem in our setup of $\mathcal{L}^{SP}$ by introducing $EC_{T,1}$ as a separate auxiliary variable and including the equation $EC_{T,1} = E[C^{\omega}_{T,1}]$ as an additional constraint in the problem.

The resulting first-order conditions are

$$\begin{aligned}
&\text{FOC}(C^{\omega}_{T,1}): && u'(C^{\omega}_{T,1}) + \lambda^{\omega}\kappa\varsigma = \mu^{\omega}(1+N) + \nu(R^* M^{\omega}_1 - 1) - \eta \quad \forall\omega \\
&\text{FOC}(F^{\omega}_2): && \beta R^* u'(C^{\omega}_{T,2}) + \lambda^{\omega} = \mu^{\omega} \quad \forall\omega \\
&\text{FOC}(N): && E\left\{\mu^{\omega}[C^{\omega}_{T,1} - (1-\rho)EC_{T,1}]\right\} = 0 \\
&\text{FOC}(\rho): && E[\mu^{\omega}]NEC_{T,1} = -\nu EC_{T,1} \\
&\text{FOC}(EC_{T,1}): && E[\mu^{\omega}]N(1-\rho) = \nu\rho + \eta
\end{aligned}$$

Combining the first-order conditions on ρ and $EC_{T,1}$, we can express the two shadow prices $\nu = -N \cdot E[\mu^{\omega}]$ and $\eta = N \cdot E[\mu^{\omega}]$ and re-write the first condition as

$$\text{FOC}(C^{\omega}_{T,1})': \ u'(C^{\omega}_{T,1}) + \lambda^{\omega}\kappa\varsigma = \mu^{\omega}(1+N) - N \cdot E[\mu^{\omega}]R^* M^{\omega}_1 \quad \forall\omega$$

Assumption 1 implies that in equilibrium, $M^{\omega}_1/E[M^{\omega}_1] = \mu^{\omega}/E[\mu^{\omega}]$ and the condition simplifies to

$$\text{FOC}(C^{\omega}_{T,1}): \ u'(C^{\omega}_{T,1}) + \lambda^{\omega}\kappa\varsigma = \mu^{\omega} \qquad \forall\omega \tag{24}$$

B Incomplete Risk Markets [Online Appendix]

In section 4 risk markets are complete (assumption 1) to simplify the exposition of our central result that an economy prone to financial accelerator effects takes on excessive dollar debt. When risk markets are incomplete in an economy with multiple goods (here: tradable and non-tradable goods), international lenders and domestic agents cannot engage in optimal risk-sharing and additional distortions in the spirit of Stiglitz (1982) arise: a social planner can introduce small deviations from the privately optimal allocations of decentralized agents at a second order cost. These deviations affect relative prices and by extension alter the payoff profile and the span of the assets available to the economy, which allows for better risk sharing in the economy and yields a first-order increase in social welfare.

In our setup, risk markets are incomplete whenever assumption 1 is violated: market incompleteness arises whenever fluctuations in domestic tradable consumption and by extension in the real exchange rate are not reflected in fluctuations in the pricing kernel of international lenders. We can think of such fluctuations for example as shocks to the pricing kernel (i.e. to the risk aversion) of international lenders that are independent of the shocks to the domestic economy. Alternatively we can think of shocks to the domestic economy $Y^{\omega}_{T,1}$ that are uncorrelated to the risk factors faced by international lenders. In both instances optimal risk sharing in a first-best world would entail that the two parties share their risks up to the point where the relative marginal valuations of their payoffs are identical across all states and $\mu^{\omega}/E[\mu^{\omega}] = M^{\omega}_1/E[M^{\omega}_1]\ \forall\omega$.

Incomplete risk markets prevent borrowers and lenders from equating their relative marginal valuations of payoffs across all states. In such situations, a constrained social planner deviates from the privately optimal intertemporal consumption allocation in order to manipulate the exchange rate as long as borrowing constraints in the economy are loose so that $\lambda^\omega = 0$.[26] We combine the social planner's first-order conditions on borrowing FOC(F_2^ω) and consumption FOC$(C_{T,1}^\omega)'$ and express the Euler equation for loose borrowing constraints as

$$u'(C_{T,2}^\omega) = u'(C_{T,1}^\omega) - \frac{N}{1+N} E[u'(C_{T,1}^\omega)] \cdot \left\{ \frac{u'(C_{T,1}^\omega)}{E[u'(C_{T,1}^\omega)]} - \frac{M_1^\omega}{E[M_1^\omega]} \right\}$$

Suppose the amount of local currency debt in the economy is positive $N > 0$ and that we experience a state ω in which domestic agents value consumption relatively more than international lenders so that the expression in curly brackets is positive. A social planner borrows less in period 1 of such a state ω than what is indicated by the privately optimal Euler equation $u'(C_{T,1}^\omega) = u'(C_{T,2}^\omega)$, incurring a second-order cost. This lowers period 1 consumption in state ω and depreciates the exchange rate, implying a lower repayment on local currency debt. This lower repayment constitutes a redistribution from lenders to borrowers in state ω and entails a first-order benefit since borrowers value consumption relatively more highly in that state. The opposite conclusions hold if $\frac{\mu^\omega}{E[\mu^\omega]} < \frac{M_1^\omega}{E[M_1^\omega]}$. Overall, the social planner's second-best interventions in risk markets improve risk-sharing by a first-order effect.

[26] When borrowing constraints are binding, the social planner's choice of F_2^ω is determined by the constraint; differences in the intertemporal valuation of consumption between decentralized agents and the social planner are reflected in the shadow price λ^ω but do not affect real allocations in the economy.