Macroprudential Policy for Internal Financial Dollarization*

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October 29, 2023

Abstract

We study macroprudential policy aimed at domestic debt denominated in different currencies. We model a small open economy with entrepreneurs and workers who save and borrow in domestic and foreign currency. Financial frictions make dollar debt on entrepreneurs' balance sheets especially disruptive when the exchange rate depreciates. Falling output causes additional depreciation; this amplification provides a rationale for de-dollarization. On the other hand, de-dollarization is costly because the dollar savings of domestic workers provide them with insurance. We characterize the social marginal benefits and costs of de-dollarization in this context. The social marginal costs are associated with a deterioration in risk-sharing and can be expressed in terms of the interest rate premium on domestic currency assets. We find that these costs are of second order around the unregulated equilibrium, but play a role for optimal policy.

Key Words: liability dollarization, macroprudential policy, exchange rates

JEL Classification Numbers: E21, F21, F41

*We are grateful to Javier Bianchi, the editor, and two anonymous referees for their insightful comments. We also thank Fernando Álvarez, Olivia Bordeu, Fernando Cirelli, Mikhail Golosov, Veronica Guerrieri, Konstantin Egorov, Elena Istomina, Greg Kaplan, Rohan Kekre, Guido Lorenzoni, Brent Neiman, Pablo Ottonello, Diego Perez, Francesco Ruggieri, Haresh Sapra, Robert Shimer, Liza Sizova, Svyatoslav Tiupin, and Harald Uhlig.

1 Introduction

Compared to advanced economies, macroprudential policy in developing economies focuses more on limiting transactions in foreign currency. Between 1990 and 2018, 11% of macroprudential policy tightening episodes in developing economies were related to foreign currency instruments, compared to 2% in advanced economies. Moreover, the use of this type of macroprudential policy has been on the rise. Figure 1 shows the number of countries tightening their limits on either savings or borrowing positions in foreign currency in a given year. There is a spike following the global financial crisis (GFC) when emerging markets experienced considerable capital inflows.

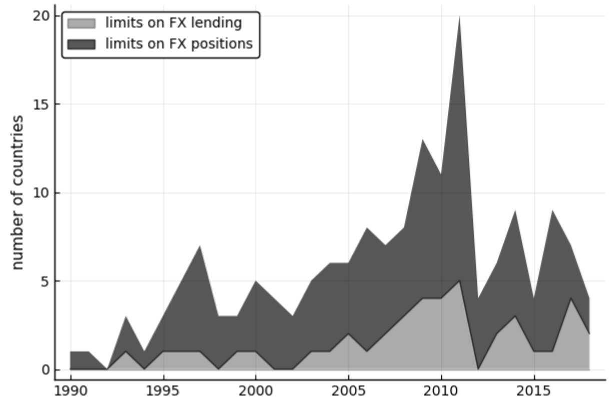
This swift policy response in the aftermath of the GFC suggests an interaction between policy and the economic literature. The latter had studied foreign currency debt as a cause of vulnerabilities since the currency crises of the late 1990s, dating back to Krugman (1999) and Mendoza (2002). A more recent literature studied more broadly how firms may over-borrow, failing to take into account the negative externalities of their borrowing on the economy as a whole and justifying the need for interventions (Lorenzoni, 2008; Bianchi, 2011). Korinek (2018) argues that the externalities associated with foreign currency debt are particularly strong.

The literature has focused mostly on cross-border borrowing, with firms borrowing from foreign investors. However, as a separate strand of the literature has shown, in emerging economies an important fraction of foreign currency financing is provided by domestic savers who use foreign currency investments as an insurance tool (Dalgic, 2018; Bocola and Lorenzoni, 2020a; Christiano et al., 2021). Interventions that limit foreign currency borrowing could harm these savers by making insurance less accessible. This motivates taking into account the domestic holdings of foreign currency debt when weighing the costs and benefits of macroprudential policy, which is what we do in this paper.

We study the optimal regulation of internal financial dollarization focusing on the insurance benefits and balance sheet costs of foreign currency assets. To conceptualize and quantify this trade-off, we build a small open economy model that combines insights from two distinct strands of literature. One of them, exemplified by Bocola and Lorenzoni (2020a), has studied the positive causes and consequences of internal dollarization. The other is the overborrowing literature which has studied pecuniary externalities in an environment with financial frictions and foreign currency debt from the normative perspective (see Bianchi and Mendoza (2020) for a review).

The essential features of our model are the following. Firms produce tradable goods, and the entrepreneurs running these firms issue bonds denominated in tradable and non-tradable goods. Debt occasionally affects their output through a borrowing limit that prevents them from pre-funding enough inputs. When this happens, the supply of tradables in the economy falls, and the relative price of non-tradables (the real exchange rate) decreases. The borrowing limit is denominated in non-tradable goods, so it tightens after a depreciation. This causes a new output

Figure 1: Tightening of Foreign Currency Macroprudential Policies (all countries)



Source: IMF Macroprudential Policy database, originally constructed by Alam et al. (2019). If a country implements more than one policy change in a given year, it gets counted as 1 in the figure. An example of a limit on FC lending would be the following, from Romania: *...the authorities introduced a limit on credit institutions' exposure to at most 300% of their equity (...) when granting foreign currency loans to unhedged borrowers....* An example of a limit on FC positions would be the following, from Indonesia: *...non-bank corporations holding external debt shall be required to hedge their foreign exchange against the rupiah with a ratio of 25%.*

contraction, launching a depreciation spiral which, following the literature, we label Fisherian amplification. These periods feature busts in real activity and an exchange rate depreciation simultaneously. We refer to debt denominated in tradables and non-tradables as "dollar debt" and "peso debt", and to the relative price of non-tradables as the exchange rate.

Firms employ households. Their wage is directly linked to output and drops in recessions, which coincide with depreciation episodes. They also consume bundles of tradable and non-tradable goods, so their purchasing power strongly depends on the exchange rate. To insure themselves against currency fluctuations, households include dollar-denominated assets in their portfolio and are willing to pay a premium on them. This premium induces firms to borrow in dollars, and as a result, households' dollar assets constitute the bulk of dollar debt on the firms' balance sheets. These dollar assets add to loans from foreign investors, who have typically been the focus of the macroprudential policy literature.

This environment features a pecuniary externality common to models with prices in borrowing constraints: agents take these prices as given and do not internalize that the price impact of their decisions might tighten the borrowing limit. The resulting overborrowing constitutes one reason for the planner in this economy to reduce debt and savings. Moreover, the two types of debt are different in that foreign currency debt does not lose real value in times of depreciation and hence generates stronger amplification. This might push the planner to target foreign currency debt specifically, leading her to decrease financial dollarization.

While this externality has been studied before, most of the normative literature has not incorporated the analysis of distributive effects and their interaction with fire sales, which is an aspect of our environment with both workers and entrepreneurs.[1] Distributive effects are present because the model features labor and a non-tradable good, both of which are exchanged within the economy. The wage and the price of non-tradables are affected by aggregate debt when the borrowing constraint binds. The impact of policy on these prices is zero-sum in nature: a drop in wages hurts workers as much as it benefits entrepreneurs, and a drop in the exchange rate hurts net buyers of non-tradables as much as it benefits net sellers. Risk-sharing properties of foreign currency assets are also specific to settings with two agents. Social benefits of changing internal financial flows come from correcting pecuniary externalities and from distributive motives. Social costs are associated with distorting domestic risk-sharing arrangements. We propose a normative approach to quantifying these benefits and costs.

In our setting, the planner moves the economy across equilibria with different debt levels by setting debt taxes. Focusing on internal flows in different currencies, we consider two types of perturbations that the planner can induce by intervening in domestic financial markets. First, we derive the net marginal benefit of internal deleveraging. This perturbation decreases the equilibrium level of debt in one currency, holding constant the amount of debt in the other. Second, we derive the net marginal benefit of de-dollarization. This perturbation keeps the total expected payout constant but changes the currency composition of the household portfolio.

Our first result is that deleveraging in each kind of debt leads to welfare changes of two types. First, there are efficiency gains. Entrepreneurs do not internalize how the binding borrowing limit reduces the supply of tradable goods, leading to exchange rate depreciation that further tightens the constraint. Deleveraging helps correct this externality. Second, deleveraging changes the exchange rate and wages, which has redistributive effects, revaluing payments between entrepreneurs and households. These effects can be socially desirable, depending on the gap between their marginal utilities in each state and the planner's weights.

Our second result is about a policy that de-dollarizes the portfolio without affecting the total value of debt. This policy is welfare-improving if the social benefits of increasing entrepreneurs' borrowing capacity are higher in states with weak local currency. In this case, the planner would like to reduce the real value of debt in these states even at the expense of increasing it in others. De-dollarizing the portfolio is a way to achieve that. Marginal benefits of de-dollarization reflect breaking the link between the real exchange rate and the tightness of the borrowing limit.

The marginal costs of de-dollarization come from a deterioration in risk-sharing. We find that these costs can be measured by a simple statistic: the difference between uncovered interest parity (UIP) violations for the two sides of the market, savers and borrowers.[2] Savers and borrowers face different violations of UIP if after-tax expected returns are different on the two sides of

[1] See Biljanovska and Vardoulakis (2022) for a paper that does incorporate heterogeneity but differs from our model in other aspects.

[2] The UIP violation is the gap between interest rates in two currencies adjusted for expected depreciation.

the market, which means that the marginal costs of de-dollarization are zero when there is no intervention. The marginal benefits discussed before, on the other hand, are generally not zero if the borrowing constraint binds at least in some states. This suggests an ordering of concerns about pecuniary externalities and risk-sharing in the context of de-dollarization: in our model, pecuniary externalities come first.

Finally, we provide a numerical illustration of these forces. We pick parameters to make the model produce a UIP violation of 3*pp* and a savings dollarization rate of 30%, empirically representative targets. The social planner looks for an allocation that balances marginal costs and benefits of intervention. At the optimum, she reduces the savings dollarization rate to 11%. Pecuniary externalities are not fully eliminated at the optimal allocation, as risk-sharing costs stop the planner from deleveraging and de-dollarizing the economy further. We also find that the optimal debt taxes turn out to be lower than the uninternalized marginal costs of debt in equilibrium. This can be interpreted as a virtuous circle: as the economy is de-dollarized, currency crises become less severe, and demand for foreign currency savings falls, making it easy to force de-dollarization on the margin.

The UIP violation observed in the unregulated equilibrium is an informative statistic. Calibrating the model to different UIP violations, we find that a higher UIP violation leads to a higher savings dollarization in the social optimum. This reinforces the view of Christiano et al. (2021), who suggest that deviations from UIP signal fundamental demand for insurance and justify higher levels of dollarization. Marginal costs of de-dollarization become relevant as the economy moves away from the unregulated equilibrium. Before that, marginal benefits dominate.

Related Literature. The literature studying overborrowing in the context of cross-border capital flows traces back to Krugman (1999), who highlighted the importance of foreign currency debt in firms' balance sheets during the emerging market crises of 1997-98. Mendoza (2002) and Arellano and Mendoza (2002) provide seminal quantitative explorations of how occasionally binding borrowing constraints affect the severity of crises. Bianchi (2011) studies normative implications in an economy with debt denominated in tradable goods but does not consider the trade-off between different types of borrowing.[3]

The nature of the externality in the model is essential to the analysis of macroprudential policies. In our model, collateral consists of non-tradable goods, so a real exchange rate depreciation tightens the borrowing constraint. Papers that have made this assumption, on which we build, include Mendoza (2002), Bianchi et al. (2016), Benigno et al. (2013), Korinek and Sandri (2016), Korinek (2018) and Mendoza and Rojas (2019). Similar to Bianchi and Mendoza (2018), we impose that entrepreneurs face a borrowing constraint that includes working capital.

Most of the papers discussed consider foreign currency borrowing from foreign agents, without distinguishing between different types of debt. Korinek (2018) argues that the externalities associ-

[3]See Korinek (2011) for a comprehensive review on capital controls.

ated with foreign currency debt are stronger than for other types of borrowing like FDI and equity. Liu et al. (2021) introduce local currency borrowing from abroad and study financial regulations when debt denomination is endogenous. The main difference between these papers and ours is that they focus on the insurance properties of each type of instrument with respect to the rest of the world, not domestically. A closely related paper is Biljanovska and Vardoulakis (2022), who study how heterogeneity between workers and entrepreneurs affects optimal macroprudential policy in an economy with foreign currency debt. The main difference is that our model incorporates domestic saving and therefore allows us to consider how macroprudential policy affects domestic risk sharing. A second difference is that we introduce debt denominated in different units and compare the externalities associated with each. Similarly to Biljanovska and Vardoulakis (2022), in our model, the optimal macroprudential policy might involve indirect redistribution through changes in wages.

Another recent strand of the literature to which we contribute introduces domestic risk sharing as an essential element when studying borrowing in foreign currency. These include Dalgic (2020), Bocola and Lorenzoni (2020a), and Christiano et al. (2021). None of them derive the optimal macroprudential policy. Dalgic (2020) is the closest paper to ours. He studies the consequences of taxes on foreign currency borrowing but does not characterize the optimal macroprudential policy nor the trade-offs between taxing local and foreign currency debt. Gutierrez et al. (2021) provide a detailed empirical analysis of the sources of UIP deviations using data from Peru.

Layout. We describe the model in Section 2. Section 3 discusses the externalities and optimal policy. Our quantitative exercise is in Section 4.

2 Model and Equilibrium

Before describing the model we briefly discuss the two standard facts that have guided theoretical research in this literature and will guide our modeling assumptions too.

Fact 1: uncovered interest parity deviation. In emerging economies, saving instruments denominated in local currency pay a higher interest rate than those denominated in foreign currency after adjusting for expected depreciation. Using detailed microdata, Gutierrez et al. (2021) find a premium of 2%. In Appendix G we describe other studies and calculate these numbers ourselves. We find deviations of similar magnitude.

This premium has been described in the literature as coming from the insurance properties of foreign currency instruments that make savers willing to accept lower returns. Gutierrez et al. (2021), Christiano et al. (2021) and Bocola and Lorenzoni (2020a), among others, hold this view. This insurance motive is present in our model. In Section 4, we calibrate the model to different values of the uncovered interest deviation and find that we need higher risk aversion by savers to match higher values of the UIP deviation.

Fact 2: banks pass currency risk to firms by extending foreign currency loans. In emerging markets, bank liabilities in foreign currency are similar in magnitude to loans extended to firms in foreign currency. This fact may partly be driven by regulation, whereby banks have limits on how much currency mismatch they can bear (see Christiano et al. (2021)). Conceptually, this matters when put next to the first fact. Firms are effectively the agent insuring savers, and there is a premium on local currency debt in equilibrium. This means that it is more costly for firms to bear dollar-denominated debt than local currency debt on their balance sheets. Otherwise, firms' demand for foreign currency financing would push local currency rates down.

In our model, dollar debt is more costly on firms' balance sheets for two reasons: entrepreneurs are potentially risk averse, and dollar debt is more likely to distort firm production through financial friction. We discuss our own calculations for this fact in Appendix G.

2.1 Model

The domestic economy consists of two periods, two goods (traded and non-traded), and two agents (entrepreneurs and workers). The traded good is the numeraire. It can be bought from and sold abroad, while the non-tradable good must be produced and consumed at home. The price of the non-traded good, p_t, is determined domestically.

Two types of financial contracts are issued by entrepreneurs at $t = 0$: a claim to one unit of tradables or non-tradables to be delivered at $t = 1$. Claims to non-tradables are only circulated within the country, while claims to tradables can also be sold abroad.

Workers. The representative worker receives a non-tradable endowment $e_t^{N,w}$ and a tradable endowment $e_t^{T,w}$ at the beginning of each period. Her preferences have the Epstein and Zin (1991) form, so the value of the worker at $t = 0$ is

$$\mathcal{V}^w = \max \ \mathcal{C}\left(c_0^{N,w}, c_0^{T,w}\right)^{1-\zeta} + \beta_w \mathbb{E}\left[\mathcal{C}\left(c_1^{N,w}, c_1^{T,w}\right)^{1-\sigma}\right]^{\frac{1-\zeta}{1-\sigma}} \tag{1}$$

$$\text{s.t. } p_0 c_0^{N,w} + c_0^{T,w} + q^T b^T + p_0 q^N b^N \leq w_0 l_0 + e_0^{T,w} + p_0 e_0^{N,w} \tag{2}$$

$$p_1 c_1^{N,w} + c_1^{T,w} \leq w_1 l_1 + e_1^{T,w} + p_1 e_1^{N,w} + b^T + p_1 b^N \tag{3}$$

Here ζ is the inverse of the intertemporal substitution elasticity, β^w is the discount factor, and σ is the inverse of the cross-state substitution elasticity. It measures risk aversion. When $\zeta = \sigma$, preferences become time-separable and feature expected utility.

Workers maximize over $(b^T, b^N, c_0^{N,w}, c_0^{T,w})$ and stochastic variables $(c_1^{N,w}, c_1^{T,w})$. Within each period, workers have Cobb-Douglas preferences over the two types of goods:

$$\mathcal{C}(c^N, c^T) = \frac{\left(c^T\right)^{1-\alpha}\left(c^N\right)^{\alpha}}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}} \tag{4}$$

This type of aggregation gives rise to price index p_t^{α}. Besides consumption goods, workers buy claims b^T and b^N at prices q^T and $p_0 q^N$, respectively. Their total income is the wage bill $w_t l_t$, the value of endowments $e_t^{T,w} + p_t e_t^{N,w}$ in both periods, and financial income $b^T + p_1 b^N$ at $t = 1$.

Workers take prices and wages as given. They freely choose the currency composition of their portfolio but only save within the country. We impose this to keep the model parsimonious. Below and in Appendix B.1 we discuss why this assumption is not crucial for our results about policy.

Entrepreneurs. The income of entrepreneurs comes from endowments $\{e_t^{T,e}, e_t^{N,e}\}$ and their profits. They produce tradable goods using labor and use the same goods as inputs. Profits are given by $f(z_t, l_t) - w_t l_t - z_t$, where $f(z_t, l_t)$ is the production function, w_t is the wage, l_t is labor and z_t is the tradable input use.

We now describe the timing going backward. At the beginning of period 1, the representative entrepreneur has three types of debt outstanding: she owes b^N units of the non-traded good and b^T units of the traded good to domestic savers and $\tilde{b}$ units of the traded good to foreign investors. Debt can affect production in the following way. Before entrepreneurs get to produce, they have to pre-fund a fraction θ of their input use z_1 by taking out a zero-interest intraday loan subject to the borrowing constraint in (5).

$$\theta z_1 + \tilde{b} + b^T + p_1 b^N \leq p_1 \bar{b} \tag{5}$$

Equation (5) states that the total amount of debt outstanding cannot exceed a limit of $\bar{b}$ units of the non-traded good.[4] This constraint occasionally prevents entrepreneurs from choosing the optimal input use z_1. Biljanovska and Vardoulakis (2022) include a share of the wage bill, which is determined locally, into the borrowing constraint. This would introduce other externalities that we shut down. At $t = 0$, there is no credit friction.

Entrepreneurs issue claims to non-traded goods at a price $p_0 q^N$ and to traded goods at two prices: q^T at home and $\tilde{q}$ abroad. These operations are subject to ad-valorem taxes, which we describe in detail below. All told, the value of an entrepreneur is

$$\mathcal{V}^e = \max\ \mathcal{C}\left(c_0^{N,e}, c_0^{T,e}\right)^{1-\zeta_e} + \beta_e \mathbb{E}\left[\mathcal{C}\left(c_1^{N,e}, c_1^{T,e}\right)^{1-\sigma_e}\right]^{\frac{1-\zeta_e}{1-\sigma_e}} \tag{6}$$

$$\text{s.t. } p_0 c_0^{N,e} + c_0^{T,e} \leq f(z_0, l_0) - w_0 l_0 - z_0 + e_0^{T,e} + p_0 e_0^{N,e} \tag{7}$$
$$+ (1-\tilde{\tau})\tilde{q}\tilde{b} + (1-\tau^T) q^T b^T + (1-\tau^N) p_0 q^N b^N + T^e$$

$$p_1 c_1^{N,e} + c_1^{T,e} + \tilde{b} + b^T + p_1 b^N \leq f(z_1, l_1) - w_1 l_1 - z_1 + e_1^{T,e} + p_1 e_1^{N,e} \tag{8}$$

$$\theta z_1 \leq p_1\left(\bar{b} - b^N\right) - b^T - \tilde{b} \tag{9}$$

[4] In Appendix D, we provide a microfoundation for this intra-day borrowing limit to be increasing in p_1. Besides the particular punishment strategy we choose in Appendix D, this feature is essential for the premium paid on non-tradable debt to be higher than for tradable debt (which is the case empirically, as we showed).

Entrepreneurs maximize over $\{z_t, l_t, c_t^{T,e}, c_t^{N,e}\}_{t=0,1}$ and $\{b^T, b^N, \tilde{b}\}$ with $\tilde{b} \geq 0$. They aggregate different goods using the same bundles $\mathcal{C}(\cdot)$ as workers, but $(\beta_e, \zeta_e, \sigma_e)$ are potentially different.

Consumption and debt repayment at $t = 1$ are financed by profits $f(z_1, l_1) - w_1 l_1 - z_1$ and the value of endowments $e_1^{T,e} + p_1 e_1^{N,e}$. At $t = 0$, entrepreneurs finance their consumption with profits $f(z_0, l_0) - w_0 l_0 - z_0$, endowments $e_0^{T,e} + p_0 e_0^{N,e}$, and revenues from issuing debt $\{b^N, b^T, \tilde{b}\}$. They pay taxes $\{\tau^N, \tau^T, \tilde{\tau}\}$ on this borrowing and receive a lump-sum transfer T^e that balances the government's budget:

$$T^e = \tilde{\tau} \cdot \tilde{q}\tilde{b} + \tau^T \cdot q^T b^T + \tau^N \cdot p_0 q^N b^N \tag{10}$$

In Appendix B.4, we study an alternative version of the model in which transfers compensate both workers and entrepreneurs for all income effects associated with changes in asset prices in the new equilibrium relative to that without intervention.

Foreign investors. Entrepreneurs can borrow in foreign currency both at home and abroad. Foreign investors supply loans $\tilde{b}$ at a price $Q(\tilde{b})$, with $Q'(\cdot) > 0$. In Section 3, we consider policies that keep $\tilde{b}$ constant across allocations that the planner implements. This simplification allows us to focus on the effects of domestic debt denominated in different currencies instead of cross-border borrowing, which has been the focus of most of the literature on macroprudential policy (see Bianchi and Mendoza (2020) for a review). In Appendix B.3, we show that the ability to set capital controls gives the social planner some control over externalities but creates additional incentives to manage the exchange rate. To keep the analysis clean, we shut this down by fixing $\tilde{b}$ when we analyze optimal policy for domestic flows.

2.2 Equilibrium

We now define the competitive equilibrium in this economy and describe some of its properties. Equilibria are indexed by a tuple $\{\tau^N, \tau^T, \tilde{\tau}, T^e\}$ of tax policy profiles. We assume inelastic labor supply $\{l_t\}_{t=0,1}$. Endowments $\{e_t^{T,w}, e_t^{T,e}, e_t^{N,w}, e_t^{N,e}\}_{t=0,1}$ are exogenous. The underlying exogenous shock is a shock to the tradable endowment $\epsilon = (e_1^{T,w}, e_1^{T,e})$. All other variables are endogenous.

Definition 1. A competitive equilibrium is a set of relative prices $\{p_t\}_{t=0,1}$, wages $\{w_t\}_{t=0,1}$, claim prices $\{q^N, q^T, \tilde{q}\}$ and quantities $\{b^N, b^T, \tilde{b}\}$, input quantities $\{z_t\}_{t=0,1}$, and consumption quantities $\{c_t^{N,w}, c_t^{T,w}, c_t^{N,e}, c_t^{T,e}\}_{t=0,1}$ such that

- $\{c_t^{N,w}, c_t^{T,w}\}_{t=0,1}$ and $\{b^N, b^T\}$ are optimally chosen by workers;
- $\{c_t^{N,e}, c_t^{T,e}\}_{t=0,1}$ and $\{b^N, b^T, \tilde{b}\}$ are optimally chosen by entrepreneurs;
- the sequences $\{z_t, l_t\}_{t=0,1}$ are optimally chosen by firms;

- the market for non-traded good clears: $c_t^{N,w} + c_t^{N,e} = y_t^{N,w} + y_t^{N,e}$ for $t = 0, 1$;
- borrowing from abroad is consistent with the supply curve for foreign loans: $\tilde{q} = Q(\tilde{b})$
- the balance of payments identity is satisfied in both periods:

$$c_0^{T,w} + c_0^{T,e} = f(z_0, l_0) - z_0 + e_0^{T,w} + e_0^{T,e} + \tilde{q}\tilde{b}$$
$$c_1^{T,w} + c_1^{T,e} = f(z_1, l_1) - z_1 + e_1^{T,w} + e_1^{T,e} - \tilde{b}$$

The last condition states that aggregate consumption of the traded good equals output net of input use $f(z_t, l_t) - z_t$, traded endowments $e_T^{T,w} + e_T^{T,e}$ and either borrowing from abroad $\tilde{q}\tilde{b}$ or debt repayment abroad $\tilde{b}$.

We now characterize the equilibrium. First, wage equals marginal product of labor:

$$w_t = f_l(z_t, l) \tag{11}$$

Second, given Cobb-Douglas aggregation,

$$(1-\alpha)p_t c_t^{N,j} = \alpha c_t^{T,j} \text{ for } j \in \{w, e\} \tag{12}$$

The relative price of non-tradables is hence

$$p_0 = \frac{\alpha}{1-\alpha} \cdot \frac{c_0^{T,w} + c_0^{T,e}}{c_0^{N,w} + c_0^{N,e}} = \frac{\alpha}{1-\alpha} \cdot \frac{f(z_0, l_0) - z_0 + e_0^{T,w} + e_0^{T,e} + \tilde{q}\tilde{b}}{e_0^{N,w} + e_0^{N,e}} \tag{13}$$
$$p_1 = \frac{\alpha}{1-\alpha} \cdot \frac{c_1^{T,w} + c_1^{T,e}}{c_1^{N,w} + c_1^{N,e}} = \frac{\alpha}{1-\alpha} \cdot \frac{f(z_1, l_1) - z_1 + e_1^{T,w} + e_1^{T,e} - \tilde{b}}{e_1^{N,w} + e_1^{N,e}} \tag{14}$$

The exogenous driver of randomness is the aggregate tradable endowment $e_1^{T,w} + e_1^{T,e}$. This endowment determines p_1 conditional on z_1, but z_1 itself changes in response to p_1, so the exchange rate is an endogenous variable with an exogenous random component.

Finally, input use z_1 at $t = 1$ is

$$z_1 = \min\left\{\overline{z}, \hat{z}\big(p_1, b^N, b^T, \tilde{b}\big)\right\} \tag{15}$$

Here $\overline{z}$ denotes the unconstrained input use in equilibrium. Since labor is supplied inelastically at l, $\overline{z}$ is given by $f_z(\overline{z}, l) = 1$. The constrained z_1 is given by $\hat{z}\big(p_1, b^N, b^T, \tilde{b}\big) = \theta^{-1}\big(p_1\big(\overline{b} - b^N\big) - b^T - \tilde{b}\big)$. Input use is determined by debt carried over from the previous period and the exchange rate.

In Appendix B.1, we show that disallowing workers to save abroad is without loss of generality as long as interest rates on external borrowing and saving only depend on the NFA (foreign borrowing by entrepreneurs net of foreign savings by workers). If workers sent some of their foreign currency savings abroad, entrepreneurs would make up for this by borrowing from foreigners in the same amount. The exchange rate would not change because the NFA would remain the same, so output and consumption would not change either. The findings in Drenik et al. (2018), who show empirically that poorer households tend to have less access to foreign currency assets, offer additional support to our restriction on foreign savings. Since workers in our model strongly depend on labor income, we map them into poorer households.

2.3 Euler equations and UIP

Optimal consumption and saving decisions are encoded in the Euler equations of the agents. Denote $C_t^w = \mathcal{C}(c_t^{N,w}, c_t^{T,w})$ and $C_t^e = \mathcal{C}(c_t^{N,e}, c_t^{T,e})$. Equilibrium claim prices satisfy

$$q^T = \beta_w \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha}\frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}}\right]\mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}}\right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{16}$$

$$q^N = \beta_w \mathbb{E}\left[\frac{p_1^{1-\alpha}}{p_0^{1-\alpha}}\frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}}\right]\mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}}\right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{17}$$

Equations (16) and (17) are standard. Those of the borrowers reflect the occasionally binding borrowing constraint:

$$(1-\tau^T)q^T = \beta_e \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha}\frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}}\cdot(1+\theta^{-1}(f_z(z_1,l)-1))\right]\mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}}\right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{18}$$

$$(1-\tau^N)q^N = \beta_e \mathbb{E}\left[\frac{p_1^{1-\alpha}}{p_0^{1-\alpha}}\frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}}\cdot(1+\theta^{-1}(f_z(z_1,l)-1))\right]\mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}}\right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{19}$$

with input use z_1 given by (15). Moreover, $(1-\tau^T)q^T \geq (1-\tilde{\tau})Q(\tilde{b})$ with equality if $\tilde{b} > 0$.

When the borrowing constraint binds, the marginal cost of issuing debt is augmented by the value of the profits $f_z(z_1, l_1) - 1$ unearned due to the inability to pre-fund additional inputs, as input use z_1 is determined by the debt hanging over from the previous period.

In Fact 1 reported at the beginning of this section we highlighted that local currency instruments typically pay a premium above saving instruments denominated in foreign currency. Our model, similar in spirit to Bocola and Lorenzoni (2020a) in this sense, delivers the direction of the uncovered interest parity deviation in equilibrium. Rewriting the prices that entrepreneurs receive for the claims, (18) and (19):

$$(1-\tau^N)q^N - (1-\tau^T)q^T\mathbb{E}\left[\frac{p_1}{p_0}\right] \propto \mathbb{C}\left[\frac{p_0^\alpha}{p_1^\alpha}\cdot\frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}}\cdot(1+\theta^{-1}(f_z(z_1,l)-1)), \frac{p_1}{p_0}\right] \tag{20}$$

Here $\mathbb{C}$ stands for covariance. Debt denominated in non-tradables is cheaper in equilibrium when this covariance is negative. One force that makes it negative is the price index p_1^α in the denominator: claims to non-tradables pay out more when the price level is higher and the marginal value of income lower. Larger α, which means more dependence on non-tradables and hence more correlation of the price index with p_1, makes this force stronger.

Another force is marginal utility of consumption: if $(C_1^e)^{-\sigma_e}$ is high when p_1 is low, foreign currency carries an insurance premium that is stronger for larger σ_e. If $\sigma_e = 0$, meaning that entrepreneurs are risk-neutral, this force disappears.

Finally, the marginal effect of input use on profits $f_z(z_1, l) - 1$, which is related to the tightness of the borrowing constraint, can be negatively correlated with p_1. Observe that by concavity $f_z(z_1, l)$ decreases in z_1, which itself increases in p_1 whenever the constraint binds. This term does not contribute to (20) if $f(\cdot)$ is linear and makes it more negative if $f(\cdot)$ is concave.

3 Planner's Problem

In this section, we present the planner's problem and describe our measure of externalities. Broadly speaking, the planner's goal is to change aggregate debt with an eye on the following effects.

First, the planner internalizes Fisherian amplification. Overborrowing translates into lower production at $t = 1$ and decreases resources available to the economy as a whole. This has been the focus of much of the normative literature on overborrowing in environments with a representative agent. Benefits from this intervention represent efficiency gains.

Second, there are distributive effects that are specific to our two-agent environment. One has to do with changes in wages at $t = 1$: a drop in the wage bill hurts workers and benefits entrepreneurs by the same amount. Another one is revaluation of the non-tradable endowments at $t = 1$. Since the market for these goods clears internally, the net buyer gains the same value that the net seller loses when the exchange rate depreciates. These effects are zero-sum in the aggregate because labor and non-traded endowments are fixed.

Policy can also redistribute income at $t = 0$ as equilibrium asset prices adjust when the planner induces a change in savings and borrowing. We abstract away from this type of redistribution to keep the analysis clean and focused on $t = 1$, the period of a potential currency crisis. This motivates our choice of welfare weights in the planner's objective, as explained below.

Finally, reducing internal dollarization leads to insurance loss, as foreign currency debt provides a safer asset to risk-averse workers. As in the overborrowing literature reviewed by Bianchi and Mendoza (2020), the cost of intervention is that it impedes consumption smoothing, both across dates and states of the world, from the agents' private perspectives. The core trade-off in our environment is that de-dollarization makes a currency crisis less severe but also deprives the agents of insurance against it.

The tools available to the planner are debt taxes $\{\tau^N, \tau^T\}$ imposed on the entrepreneurs at $t = 0$. The proceeds are rebated in the same period. To focus on the welfare effects of debt held internally, b^N and b^T, we abstract away from cross-border borrowing by keeping constant $\tilde{b}$. This fixes both repayment to foreigners at $t = 1$ and inflows at $t = 0$, which equal $\tilde{q}\tilde{b} = Q(\tilde{b})\tilde{b}$.

From the point of view of the borrowers, internal and external foreign currency debt are perfect substitutes. When faced with a tax on internal debt b^T, their demand for external loans may adjust. To prevent this, we assume another authority that imposes a capital control tax $\tilde{\tau}$ as a function of $\{\tau^N, \tau^T\}$ set by the planner. This tax adjusts so that total flows $\tilde{q}\tilde{b}$ into the economy at $t = 0$ are constant. Perfect substitution between $\tilde{b}$ and b^T implies that

$$(1 - \tilde{\tau})Q(\tilde{b}) = (1 - \tau^T)q^T \tag{21}$$

The revenue from this tax, $\tilde{\tau}\tilde{q}\tilde{b}$, is rebated to the entrepreneurs at the same period.

Planner's problem. Let $\phi \in [0, 1]$ be the planner's weight on workers. The planner solves

$$\max \phi \left((C_0^w)^{1-\zeta} + \beta_w \mathbb{E}[(C_1^w)^{1-\sigma}]^{\frac{1-\zeta}{1-\sigma}} \right) + (1 - \phi) \left((C_0^e)^{1-\zeta_e} + \beta_e \mathbb{E}[(C_1^e)^{1-\sigma_e}]^{\frac{1-\zeta_e}{1-\sigma_e}} \right) \tag{22}$$

$$\text{s.t. } p_0^\alpha C_0^w = e_0^{w,T} + p_0 e_0^{N,w} - p_0 q^N b^N - q^T b^T \tag{23}$$

$$p_0^\alpha C_0^e = e_0^{e,T} + p_0 e_0^{e,N} + p_0 q^N b^N + q^T b^T + \tilde{q}\tilde{b} \tag{24}$$

$$p_1^\alpha C_1^w = e_1^{w,T} + p_1 e_1^{w,N} + w_1 l + b^T + p_1 b^N \tag{25}$$

$$p_1^\alpha C_1^e = e_1^{e,T} + p_1 e_1^{e,N} + f(z_1, l) - w_1 l - z_1 - b^T - p_1 b^N - \tilde{b} \tag{26}$$

$$q^T = \beta_w \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha} \frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}} \right] \mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}} \right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{27}$$

$$q^N = \beta_w \mathbb{E}\left[\frac{p_1^{1-\alpha}}{p_0^{1-\alpha}} \frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}} \right] \mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}} \right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{28}$$

$$(1 - \tau^T)q^T = \beta_e \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha} \frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}} \cdot (1 + \theta^{-1}\delta_1(f_z(z_1, l) - 1)) \right] \mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}} \right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{29}$$

$$(1 - \tau^N)q^N = \beta_e \mathbb{E}\left[\frac{p_1^{1-\alpha}}{p_0^{1-\alpha}} \frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}} \cdot (1 + \theta^{-1}\delta_1(f_z(z_1, l) - 1)) \right] \mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}} \right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{30}$$

$$p_1 = \frac{\alpha}{1 - \alpha} \frac{f(z_1, l) - z_1 + e_1^{w,T} + e_1^{e,T} - \tilde{b}}{e_1^{w,N} + e_1^{e,N}} \tag{31}$$

$$z_1 = \min\left\{ \bar{z}, \theta^{-1}(p_1(\bar{b} - b^N) - b^T - \tilde{b}) \right\} \tag{32}$$

$$w_1 = f_l(z_1, l) \tag{33}$$

Maximization is over $\{C_0^w, C_0^e, b^T, b^N, q^T, q^N, \tau^T, \tau^N\}$ and $\{C_1^w, C_1^e, p_1, z_1, w_1\}$ for any realization of the traded endowments $\epsilon = (e_1^{w,T}, e_1^{e,T})$.

The constraints (23) and (24) ensure budget feasibility at $t = 0$, while (25) and (26) ensure budget feasibility at $t = 1$ for any realization of ϵ. These constraints already incorporate the optimal aggregation of tradables and non-tradables into consumption bundles $C_t^j = \mathcal{C}(c_t^{T,j}, c_t^{N,j})$ for $j \in \{w, e\}$. Implementability constraints (27), (28), (29), and (30) make the planner respect asset choice of agents given prices and taxes. The constraint (31) relates the exchange rate at $t = 1$ to the supply of tradables and non-tradables for every ϵ. Finally, (32) and (33) make the planner respect the optimal input choice of entrepreneurs given debt and prices.

We make three observations about the planner's problem. First, because the fiscal proceeds are rebated to the entrepreneurs at $t = 0$, taxes do not appear in the budget constraint (24). They can be set residually to satisfy (29) and (30). Second, asset prices q^T and q^N only enter the budget constraints at $t = 0$ with opposite signs. If the planner's weights rule out redistribution motives at $t = 0$, the effect of policy on q^T and q^N does not appear in the characterization of the optimum.

Finally, given b^T and b^N, the system of (31), (32), and (33) can be solved independently of other equations for any ϵ. Hence, (p_1, z_1, w_1) can be written as functions of (b^T, b^N, ϵ). We express z_1 as a function $z_1 = Z(b^T, b^N, \epsilon)$, $p_1 = P(z_1, \epsilon) = P(Z(b^T, b^N, \epsilon), \epsilon)$ and $w_1 = W(z_1) = W(Z(b^T, b^N, \epsilon))$. The functions $Z(\cdot)$, $P(\cdot)$, and $W(\cdot)$ provide relationships between endogenous equilibrium objects across equilibria that feature different portfolios (b^T, b^N).

Budget constraints (23), (24), (25), and (26) can then be combined with (27) and (28) to solve for consumption and asset prices. This means that equilibria in the model can be indexed by (b^T, b^N). Because of this, we treat the planner's problem as choosing debt levels b^T and b^N.

Formally, for a fixed pair (b^T, b^N), define $\mathcal{W}(b^T, b^N)$ to be the value of the objective in (22) maximized over $\{C_0^w, C_0^e, q^T, q^N, \tau^T, \tau^N\}$ and $\{C_1^w, C_1^e, p_1, z_1, w_1\}$ for any realization of the traded endowments $\epsilon = (e_1^{w,T}, e_1^{e,T})$. Debt levels (b^T, b^N) are parameters in this maximization problem, and the interpretation of $\mathcal{W}(b^T, b^N)$ is the maximum welfare that the economy can achieve when the taxes make the agents optimally choose this portfolio.

We next study the derivatives of $\mathcal{W}(b^T, b^N)$. To this end, we first calculate how p_1 and w_1 change as the economy moves between equilibria with marginally different z_1, and then compute the changes in z_1 itself as equilibrium pairs (b^T, b^N) vary. Define the following objects:

$$\mathcal{D}_1^w \equiv \frac{\partial W}{\partial z_1} = f_{zl}(z_1, l) \tag{34}$$

$$\mathcal{D}_1^p \equiv \frac{\partial P}{\partial z_1} = \frac{\alpha}{(1-\alpha)(e_1^{w,N} + e_1^{e,N})} \cdot (f_z(z_1, l_1) - 1) \tag{35}$$

The marginal effect $\mathcal{D}_1^w$ is positive as long as labor and materials are not perfect substitutes. The marginal effect of the equilibrium input use on the exchange rate is only positive when the constraint binds and $f_z(z_1, l_1) - 1 > 0$. Because firms optimize, in the unconstrained optimum, they would reach the point around which the net supply of tradables (output net of input use) does not change locally.

Taking these derivatives is a step towards computing the marginal effects of changes in (b^T, b^N) between equilibria. To complete this, we need to find the total derivative of z_1 with respect to b^T and b^N and apply the chain rule. Define $\delta_1 = \mathbb{1}\{z_1 < \bar{z}\}$ an indicator function taking value 1 when the borrowing constraint binds. The total derivative with respect to b^T is

$$\mathcal{Z}_1 \equiv \frac{dz_1}{db_1^T} = -\frac{\delta_1}{\theta - \delta_1 \mathcal{D}_1^p \left(\bar{b} - b^N\right)} = -\theta^{-1}\delta_1 - \underbrace{\frac{\theta^{-1}\delta_1 \mathcal{D}_1^p \left(\bar{b} - b^N\right)}{\theta - \delta_1 \mathcal{D}_1^p \left(\bar{b} - b^N\right)}}_{\text{Fisherian amplification}} \leq -\theta^{-1}\delta_1 \tag{36}$$

The total derivative with respect to b^N is simply $p_1 \mathcal{Z}_1$. The fact that the borrowing limit depends on the relative price of non-tradables is reflected in the term $\delta_1 \mathcal{D}_1^p$ in the denominator. The relative price of non-tradables is affected by changes in output, and this spirals back into output through the borrowing limit.

The first term in the decomposition of $\mathcal{Z}_1$ in (36), $-\theta^{-1}\delta_1$, is taken into account by entrepreneurs who realize that borrowing may affect their profit through the constraint. However, they underestimate the strength of this connection. They do not take into account the equilibrium nature of the exchange rate, which prevents them from seeing that they make the constraint tighten more when production declines.

We set the weight ϕ in the planner's problem that eliminates redistributive motives at $t = 0$. For a specific allocation, we assume that ϕ satisfies $\phi(1-\zeta)(C_0^w)^{-\zeta} = (1-\phi)(1-\zeta_e)(C_0^e)^{-\zeta_e}$. This equates the planner's marginal value of allocating a unit of consumption to workers and entrepreneurs at $t = 0$. To be clear, the planner takes this weight as given. Even as it changes C_0^w and C_0^e on the margin, the planner ignores how ϕ changes because of this.

We can now characterize the marginal benefits of changing debt levels b^T or b^N. Continuing to use the notation $\mathcal{W}(b^T, b^N)$ and denoting the marginal utilities of both agents at $t = 0$ by $\mathcal{U}_0 = \phi(1-\zeta)(C_0^w)^{-\zeta} = (1-\phi)(1-\zeta_e)(C_0^e)^{-\zeta_e}$,

Proposition 1. The marginal benefits of increasing b^T and b^N are

$$\frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^T} = \mathbb{E}[\Lambda^e \underbrace{(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1)}_{\text{Fisherian amplification}}] + \mathbb{E}[(\Lambda^w - \Lambda^e)\underbrace{\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)}_{\text{redistribution}}] + \tau^T q^T \tag{37}$$

$$\frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^N} = \mathbb{E}[\Lambda^e p_1(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1)] + \mathbb{E}[(\Lambda^w - \Lambda^e) p_1 \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)] + p_0 \tau^N q^N \tag{38}$$

Here $m_1^w = b^N + e_1^{N,w} - c_1^{N,w}$ is the net sales of non-tradables by the workers, and Λ^w and Λ^e are the pricing kernels of the agents:

$$\Lambda^w = \beta^w \frac{p_1^{-\alpha}(C_1^w)^{-\sigma}}{p_0^{-\alpha}(C_0^w)^{-\sigma}} \mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}}\right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{39}$$

$$\Lambda^e = \beta^e \frac{p_1^{-\alpha}(C_1^e)^{-\sigma_e}}{p_0^{-\alpha}(C_0^e)^{-\sigma_e}} \mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}}\right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{40}$$

The marginal benefits consist of three parts. First, there is Fisherian amplification. The object $(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1)$ is the change in the profit of the entrepreneurs coming through the equilibrium input use. It contains $\mathcal{Z}_1 + \theta^{-1}\delta_1$ instead of just $\mathcal{Z}_1$ because the entrepreneurs do realize that their input use is reduced by debt in states in which the constraint binds ($\delta_1 = 1$). What they do not realize is the Fisherian amplification of this reduction through the exchange rate, as shown in (36). This term is non-positive because the object under the expectation sign is either zero (when the constraint is slack and $f_z(z_1, l) = 1$) or negative when the constraint binds and $\mathcal{Z}_1 + \theta^{-1}\delta_1 < 0$. Through this channel, increasing foreign currency debt b^T is costly.

Second, there is a redistributive part. The object under the expectation sign is the change in workers' income coming through wage and exchange rate changes. These changes are not internalized because the workers do not take into account the general equilibrium in p_1 and w_1 when they make decisions. Informally, we can write the payoff of their foreign currency assets as

$$(\text{true payoff})_{t=1} = (\text{claim payout})_{t=1} + \underbrace{\mathcal{Z}_1\mathcal{D}_1^w l + \mathcal{Z}_1\mathcal{D}_1^p m_1^w}_{\text{not internalized}} \tag{41}$$

The sign of net sales from the worker's perspective is generally ambiguous since it depends on endowment allocations. The sign of $\mathcal{Z}_1\mathcal{D}_1^w$ is negative since $\mathcal{Z}_1$ is negative when the constraint binds and zero otherwise, while $\mathcal{D}_1^w$ is positive unless $f(z, l)$ is affine. The relevant discount rate for the redistribution term is $\Lambda^w - \Lambda^e$ because the markets for the non-traded good and labor clear internally, so workers gain the same value that entrepreneurs lose.

Finally, there is a marginal benefit $\tau^T q^T$ from transferring resources to the entrepreneurs at $t = 0$ through borrowing. This comes from the difference in prices that the planner and the entrepreneurs assign to assets in equilibrium. From the entrepreneurs' perspective, the benefits of additional borrowing should be zero on the margin because they already optimize. However, they do not realize that the choice of b^T affects the tax proceeds $\tau^T q^T b^T$ rebated to them, while the planner does.

The marginal benefit of increasing b^N is similar but includes an additional p_1 under the expectation sign. This means that the impact of domestic currency debt on welfare additionally depends on the covariance of the exchange rate with the un-internalized marginal effects. We can exploit this fact to compute the marginal benefit of changing the currency composition of the debt portfolio in the economy.

Consider the following change in debt levels: let b^N increase and b^T simultaneously decrease by the same amount multiplied by $\mathbb{E}[p_1]$. The increase in b^N raises the payouts in proportion to p_1 in each state, and the decrease in b^T takes away a portion that is constant across states, while the expected payout is unchanged.

Formally, the marginal change in welfare we compute is

$$\Delta = \frac{1}{p_0 \mathcal{U}_0} \left(\frac{\partial \mathcal{W}}{\partial b^N} - \mathbb{E}[p_1] \frac{\partial \mathcal{W}}{\partial b^T} \right) \tag{42}$$

Informally, this perturbation replaces a non-contingent portion of the savers' portfolio with a more volatile one. It also increases the correlation between their marginal utility and the exchange rate, effectively taking away insurance. The benefit is that this perturbation might make balance sheet effects milder and change their correlation with the exchange rate as well. We can formally decompose the change in welfare Δ as follows:

Proposition 2. The marginal benefit of de-dollarization is

$$\Delta = \underbrace{\mathbb{C}\left[\Lambda^e(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1), \frac{p_1}{p_0}\right]}_{\text{aligning amplification with exchange rate}} + \underbrace{\mathbb{C}\left[(\Lambda^w - \Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l), \frac{p_1}{p_0}\right]}_{\text{aligning redistribution with exchange rate}}$$
$$- \underbrace{(\Delta^w_{UIP} - \Delta^e_{UIP})}_{\text{insurance wedge}} \tag{43}$$

The last term includes violations of uncovered interest parity (UIP):

$$\Delta^w_{UIP} = q^T \mathbb{E}\left[\frac{p_1}{p_0}\right] - q^N \tag{44}$$

$$\Delta^e_{UIP} = (1 - \tau^T) q^T \mathbb{E}\left[\frac{p_1}{p_0}\right] - (1 - \tau^N) q^N \tag{45}$$

In contrast to the intervention in Proposition 1, de-dollarization affects insurance: both the total amount and how it is distributed. This is evidenced by the fact that each term in (43) is a covariance. Proposition 1 measures the value of an additional unit of consumption resulting from the intervention, either generated for the economy as a whole or redistributed. In contrast, Proposition 2 describes the value of aligning this extra unit with the exchange rate distribution.

The first term in Δ captures the benefits of changing the co-movement between the exchange rate and the uninternalized effects of debt on profits. Since $\mathcal{Z}_1 + \theta^{-1}\delta_1 \leq 0$, this term is positive if the states with low p_1 (domestic currency depreciates) also feature a high marginal utility of entrepreneurs Λ^e or strong general equilibrium effects, meaning $(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l)-1)$ is high in absolute value. Intuitively, if the welfare costs of these un-internalized general equilibrium effects are strong in times of depreciation, de-dollarizing debt should weaken them.

The second term in Δ has the same interpretation but concerns the redistributive effects of changes in wages and exchange rate rather than firm profits. Since $\mathcal{Z}_1 \leq 0$, this term is positive if the states with low p_1 (depreciated domestic currency) also feature strong general equilibrium effects, meaning $\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)$ is high in absolute value. The gap between marginal utilities $\Lambda^w - \Lambda^e$ also drives this covariance up if it is high in times of depreciation.

The third term captures risk-sharing. The deviation from UIP on the worker side measures their demand for insurance. It contributes negatively to the benefits of de-dollarization since de-dollarizing the savers' portfolio makes it lose hedging value. At the same time, the deviation from UIP on the entrepreneur side enters positively. De-dollarization makes their liabilities more contingent and insures them against depreciation. In contrast to the second term, which only treats uninternalized effects, this "insurance wedge" accounts for the whole distribution of consumption and its correlation with the exchange rate, measuring how well risk is shared in the economy.

Both covariance terms are generally non-zero if the constraint binds in a positive measure of states. On the contrary, the insurance term, as seen from (44) and (45), equals zero at zero taxes. In the unregulated equilibrium, UIP violation is equalized across agents. Hence, insurance effects are of second order and are dominated by the covariance terms around the unregulated equilibrium.

The implication is that the uninternalized effects of debt on wages and the exchange rate are the primary concern when the planner considers small interventions around the unregulated equilibrium. The insurance wedge between savers to borrowers becomes important as the intervention progresses, but when the planner determines whether it needs to intervene at all, insurance concerns do not matter on the margin.

At the social optimum, the marginal benefits of increasing both types of debt are zero. We formulate this as a corollary to Proposition 1:

Corollary 1. At the social optimum,

$$\tau^T q^T = -\mathbb{E}[\Lambda^e(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l)-1) + (\Lambda^w-\Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)] \tag{46}$$

$$\tau^N q^N = -\mathbb{E}\left[\Lambda^e(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l)-1)\cdot\frac{p_1}{p_0}\right] - \mathbb{E}\left[(\Lambda^w-\Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\cdot\frac{p_1}{p_0}\right] \tag{47}$$

This corollary shows how the optimal allocation can be computed in practice. The expressions (46) and (47) can be used to eliminate the taxes from Euler equations (18) and (19) of the entrepreneurs, which can then be combined with Euler equations (16) and (17) of the workers.

Simplified example. We now specialize the setup to take a closer look at the marginal benefits of our second policy experiment, de-dollarization. Suppose that $\theta = 1$ and $f(z, l)$ is separable over z and l. Separability shuts down the wage channel: $\mathcal{D}_1^w$ is constant across states and does not co-move with the exchange rate. The optimal value of z_1 does not depend on l.

Take the following limits: $l \to 0$, $\alpha \to 0$, $e_1^{N,w} + e_1^{N,e} \to 0$, and $\alpha/(e_1^{N,w} + e_1^{N,e}) \to 1$. Endowments and consumption of non-tradables are zero in the limit, but there is still a well-defined exchange rate that can be used to denominate domestic currency debt: $p_1 = f(z_1, 0) - z_1 + e_1^{T,w} + e_1^{T,e} - \tilde{b}$. The net sales of non-tradables by the workers are simply equal to $m_1^w = b^N$.

Suppose further that $\epsilon = (e_1^{T,w}, e_1^{T,e})$ takes just two values. This implies that the markets are complete, and there is full risk-sharing before intervention. Denoting $\gamma(\epsilon) = f_z(z_1(\epsilon), 0) - 1$, we can write the condition $\Lambda^w(\epsilon) = (1 + \gamma(\epsilon))\Lambda^e(\epsilon)$ for both values of ϵ. Notice that $\Lambda^w(\epsilon) - \Lambda^e(\epsilon) > 0$ whenever $\gamma(\epsilon) > 0$. This is because the marginal value of debt for entrepreneurs reflects the profit implications of the borrowing constraint as well as marginal utility. If the constraint binds in some states, being in debt in these states is costly, so their marginal utility in equilibrium has to be lower than that of workers as compensation. As a result, the planner may have incentives to redistribute to workers.

Consider marginal benefits of de-dollarization at the unregulated equilibrium. Plugging the risk-sharing condition into the expression for Δ in Proposition 2,

$$\Delta = \mathbb{C}\left[\Lambda^e(\epsilon)\gamma(\epsilon) \cdot (\mathcal{Z}_1(\epsilon) + 1 + \mathcal{Z}_1(\epsilon)\mathcal{D}_1^p(\epsilon)b^N), \frac{p_1(\epsilon)}{p_0}\right] \tag{48}$$

Notice that the wedge between UIP violations is zero since we evaluate Δ at the unregulated equilibrium. One takeaway from (48) is that if the constraint never binds and $\gamma = 0$, there are no benefits to de-dollarizing the portfolio or any other departure from the competitive equilibrium.

If $\gamma > 0$, debt has uninternalized effects through the borrowing constraint, and there are benefits to de-dollarization. In the limit we consider, gains arise from two sources. First, the strength of the Fisher amplification $\gamma(\epsilon)(\mathcal{Z}_1(\epsilon) + 1)$ discounted with the entrepreneurs' discount factor $\Lambda^e(\epsilon)$ can be correlated with $p_1(\epsilon)$. Through this channel, portfolio de-dollarization is beneficial if the covariance is positive, meaning domestic currency depreciates in states when the Fisher amplification is strongly negative.

Second, $p_1(\epsilon)$ can be correlated with the marginal effect of debt on the workers' domestic currency income b^N, which equals $\mathcal{Z}_1(\epsilon)\mathcal{D}_1^p(\epsilon)b^N$ and is discounted with $\Lambda^w(\epsilon) - \Lambda^e(\epsilon) = \gamma(\epsilon)\Lambda^e(\epsilon)$ because it is a payment between agents. De-dollarization, again, is beneficial if the covariance is positive, meaning that non-tradables depreciate in states when marginal effect of input use on the exchange rate is strongly negative.

Plugging the expressions for $\mathcal{Z}_1(\epsilon)$ and $\mathcal{D}_1^p(\epsilon)$ in this example,

$$\Delta = -\,\mathbb{C}\left[(\underbrace{\Lambda^e(\epsilon)\gamma(\epsilon)(\bar{b}-b^N)}_{\text{Fisher amplification}} + \underbrace{\Lambda^e(\epsilon)\gamma(\epsilon)b^N}_{\text{revaluation}}) \cdot \frac{\gamma(\epsilon)}{1-\gamma(\epsilon)(\bar{b}-b^N)}, \frac{p_1(\epsilon)}{p_0}\right] \tag{49}$$

Here $\Lambda^e(\epsilon)\gamma(\epsilon)$ is both a measure of the tightness of the borrowing constraint and the weight the planner puts on redistribution through revaluation of domestic currency debt. The first summand, labeled Fisher amplification, reflects the co-movement of entrepreneurs' intraday borrowing capacity $p_1(\bar{b}-b^N) - b^T - \tilde{b}$ with the exchange rate, hence the multiplier $\bar{b}-b^N$. The second summand, labeled revaluation, reflects co-movement between the exchange rate and the non-tradable payments from entrepreneurs to workers $p_1 b^N$, hence the multiplier b^N.

The multiplier $\gamma(\epsilon)/(1-\gamma(\epsilon)(\bar{b}-b^N))$ in (49) is what $\mathcal{Z}_1(\epsilon)\mathcal{D}_1^p(\epsilon)$ is equal to in this example. This multiplier amplifies the covariance if $f(\cdot)$ is concave: $\gamma(\epsilon)$ decreases in $z_1(\epsilon)$, but both $z_1(\epsilon)$ and $p_1(\epsilon)$ increase in the total traded endowment $e_1^{T,w}+e_1^{T,e}$, so the correlation between $\gamma(\epsilon)/(1-\gamma(\epsilon)(\bar{b}-b^N))$ and $p_1(\epsilon)$ is negative. Intuitively, if marginal effects $\mathcal{Z}_1(\epsilon)\mathcal{D}_1^p(\epsilon)$ are stronger when the exchange rate depreciates, co-movement between the borrowing limit and $p_1(\epsilon)$ creates even more co-movement between $p_1(\epsilon)$ and incomes, giving the planner more incentives to de-dollarize internal flows.

Given Corollary 1, we can also verify that the optimal taxes τ^T and τ^N are different, even though markets are complete. Suppose, toward a contradiction, that $\tau^T = \tau^N = \tau$. Using (46) and (47), plugging the expressions for $\mathcal{Z}_1$ and $\mathcal{D}_1^p$, and using the fact that $(1-\tau)\Lambda^w(\epsilon) = (1+\gamma(\epsilon))\Lambda^e(\epsilon)$, $q^T = \mathbb{E}[\Lambda^w(\epsilon)]$, and $q^N = \mathbb{E}[\Lambda^w(\epsilon)\cdot p_1(\epsilon)/p_0]$, it is necessary for $\tau^T = \tau^N$ that

$$0 = \mathbb{C}\left[\frac{\gamma(\epsilon)}{1+\gamma(\epsilon)}\frac{(1-\tau)\bar{b}\gamma(\epsilon) + \tau b^N(1+\gamma(\epsilon))}{1-\gamma(\epsilon)(\bar{b}-b^N)}, \Lambda^w(\epsilon)R^x(\epsilon)\right] \tag{50}$$

Here $R^x(\epsilon) = 1/q^T - p_1(\epsilon)/(p_0 q^N)$ is the excess return on dollar-denominated assets.

It is easy to see that this condition does not hold generically. Suppose $\Lambda^e(\epsilon)$ is constant, making entrepreneurs risk-neutral. Then, $\Lambda^w(\epsilon)$ is proportional to $1+\gamma(\epsilon)$. The first term increases in $\gamma(\epsilon)$, and the second one increases in $\gamma(\epsilon)$ and decreases in $p_1(\epsilon)$, which itself decreases in $\gamma(\epsilon)$ if $f(\cdot)$ is concave. The covariance in (50) is hence positive, reflecting that the strength of amplification correlates with the exchange rate, which rationalizes taxing two types of debt at different rates. Completing the markets does not neutralize this state dependence in amplification.

A special case that shuts the state dependence down is that with a linear $f(\cdot)$ and, hence, a constant $\gamma(\epsilon)$. The borrowing constraint always binds provided that $f_z(z,l) - 1 = \gamma > 0$. The marginal benefit of de-dollarization at zero taxes further simplifies to

$$\Delta = -\,\frac{\bar{b}\gamma}{1-\gamma(\bar{b}-b^N)} \cdot \mathbb{C}\left[\gamma\Lambda^e(\epsilon), \frac{p_1(\epsilon)}{p_0}\right] = -\frac{\bar{b}\gamma}{1-\gamma(\bar{b}-b^N)} \cdot \frac{\gamma\Delta_{UIP}}{1+\gamma} \tag{51}$$

The last equality follows from the fact that $q^T = (1+\gamma)\mathbb{E}[\Lambda^e]$ and $q^N = (1+\gamma)\mathbb{E}\left[\Lambda^e \cdot p_1/p_0\right]$ taken together with the definition of UIP violation $\Delta_{UIP} = q^N - q^T\mathbb{E}[p_1/p_0]$. The benefits of de-dollarizing the portfolio on the margin are greater when the UIP deviation observed in equilibrium (which is negative) is larger in absolute value. This is intuitive because the UIP violation measures co-movement between the marginal utility of agents and the exchange rate, which de-dollarization alleviates by making the borrowing limit depend less on $p_1(\epsilon)$.

Importantly, (51) is a local effect, meaning that it only applies to the unregulated state of the economy and small interventions around it. A larger UIP violation does not necessarily imply a less dollarized socially optimal portfolio. De-dollarization leads to a deterioration of risk-sharing in the economy, and, as argued by Christiano et al. (2021), a larger observed departure from UIP may indicate strong fundamental demand for insurance and hence the importance of risk-sharing, leading to more dollarization in social optimum. We study this in a numerical example in Section 4.

4 Numerical Illustration

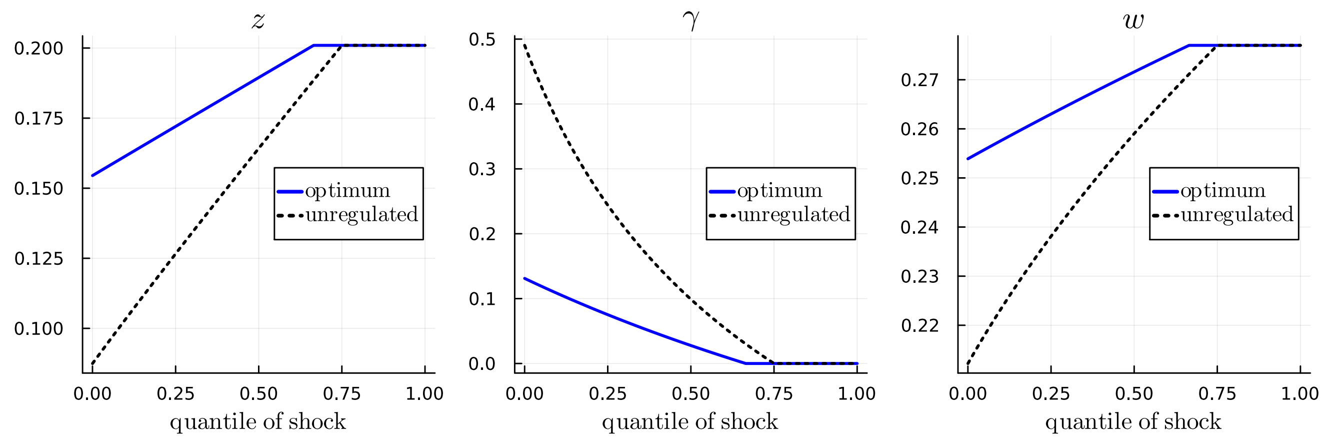
In this section we provide a numerical illustration of optimal policy. The model is fairly simple and our policy experiment, which focuses on domestic flows in different currencies, is stylized. We therefore do not interpret the results as quantitative targets for optimal dollarization in a more realistic model. Instead, we aim to illustrate the magnitude of the forces described in Section 3.

Our choice of parameters is intended to simplify the model as much as possible. Entrepreneurs have linear utility, meaning that they are risk-neutral and have infinite elasticity of intertemporal substitution. Production function $f(\cdot)$ has a constant elasticity of substitution between z and l equal to 1.25. The share of non-tradables in consumption is $\alpha = 0.5$ as in Bianchi and Mendoza (2020), and the share of pre-fundable tradable inputs is $\theta = 1$.

We calibrate the household block and the state of the economy at $t = 0$ to deliver a deposit dollarization of 30%, a dollar interest rate of 5%, and a UIP violation of $3pp$. To do this, we take advantage of Epstein-Zin preferences that allow for $\zeta \neq \sigma$. We set $\zeta = 0.6$, taking the estimates from Chen et al. (2013), and our calibration procedure results in the value $\sigma = 2.77$ for risk-aversion. Appendix C fully describes the parameterization.

The exogenous driving force of the model is the shock to the tradable endowment. We assume it has a continuous distribution and approximate it on a grid. In the unregulated equilibrium, the borrowing constraint binds 75% of the time. In these states (low realizations of the traded endowment), z_1 is determined by the borrowing constraint (9) and depends on the traded endowment through the exchange rate. The marginal product of traded inputs is above the marginal cost, so $\gamma = f_z(z_1, l) - 1 > 0$. The wage is depressed relative to the unconstrained value. If the shock realization is above the 75-th percentile, the borrowing constraint is slack, z_1 and w_1 are fixed, and $\gamma = f_z(z_1, l) - 1 = 0$. Figure 2 plots these variables as a function of the quantile of the shock, with

Figure 2: Input use z, marginal profits $\gamma = f_z(z,l) - 1$, and wage w as functions of the realization of the shock to tradable endowments at $t = 1$. The horizontal axis shows the quantile of the realization, from lowest to highest tradable endowments. Dotted lines represent the unregulated equilibrium, and solid lines correspond to the social optimum.



dotted lines representing the unregulated economy.

In the unconstrained equilibrium, workers save $b^N = 0.7$ in non-tradables and $b^T = 0.3$ in tradables. Entrepreneurs borrow $(b^N, b^T) = (0.7, 0.3)$ from them and an additional $\tilde{b} = 0.1$ from abroad. In the social optimum, workers' portfolio changes to $(b^N, b^T) = (0.88, 0.11)$. The constraint binds in 63% of the states, as opposed to 75% before the intervention. This happens because the value of entrepreneurs' outstanding debt falls more in times of depreciation since the share of domestic currency has increased. This creates space to finance more inputs: there are states (between 63-th and 75-th percentiles of the shock distribution) for which the borrowing constraint binds in the unregulated equilibrium but is slack in the optimum, so z reaches the level that ensures $f_z(z,l) - 1 = 0$. Solid lines in Figure 2 show this.

We next calculate the marginal benefits of decreasing debt of each type and the marginal benefits of de-dollarization. In particular, we use expressions from Proposition 1 and Proposition 2 to calculate the efficiency benefits resulting from limiting Fisherian amplification and the redistributive benefits resulting from changing wage and exchange rate profiles. We use the following notation for the Fisherian terms:

$$\mathcal{F}^T = -\mathbb{E}[\Lambda^e(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1,l) - 1)] \tag{52}$$

$$\mathcal{F}^N = -\mathbb{E}\left[\Lambda^e(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1,l) - 1) \cdot \frac{p_1}{p_0}\right] \tag{53}$$

$$\mathcal{F}^\Delta = \mathbb{C}\left[\Lambda^e(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1,l) - 1), \frac{p_1}{p_0}\right] \tag{54}$$

The notation for the redistributive terms is:

$$\mathcal{R}^T = -\mathbb{E}[(\Lambda^w - \Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)] \tag{55}$$

$$\mathcal{R}^N = -\mathbb{E}\left[(\Lambda^w - \Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l) \cdot \frac{p_1}{p_0}\right] \tag{56}$$

$$\mathcal{R}^\Delta = \mathbb{C}\left[(\Lambda^w - \Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l), \frac{p_1}{p_0}\right] \tag{57}$$

Proposition 1 shows that the marginal benefit of decreasing b^T, appropriately scaled by marginal utility $\mathcal{U}_0$, is given by $\mathcal{F}^T + \mathcal{R}^T - \tau^T q^T$. The marginal benefit of decreasing b^N, scaled by $p_0\mathcal{U}_0$, equals $\mathcal{F}^N + \mathcal{R}^N - \tau^N q^N$. Proposition 2 shows that marginal benefits of de-dollarizing internal flows while keeping expected payouts the same is $\mathcal{F}^\Delta + \mathcal{R}^\Delta - (\Delta^w_{UIP} - \Delta^e_{UIP})$. Table 1 reports these numbers for our numerical exercise.

Table 1: marginal benefits of deleveraging and de-dollarization (percentage points)

	decreasing b^T			decreasing b^N			de-dollarization		
	$\mathcal{F}^T$	$\mathcal{R}^T$	total	$\mathcal{F}^N$	$\mathcal{R}^N$	total	$\mathcal{F}^\Delta$	$\mathcal{R}^\Delta$	total
unregulated	0.767	10.029	10.796	0.679	9.103	9.782	0.083	0.863	0.946
optimum	0.029	7.254	7.283	0.026	6.63	6.656	0.003	0.588	0.591

In our example, the marginal benefits of decreasing dollar debt amount to just below 11*pp* when evaluated at the unregulated equilibrium. Of this, 7% is coming from the Fisher term. At the social optimum, the Fisher and redistributive terms combine to just zbove 7*pp*, and the overall marginal benefit of decreasing tradable debt further is zero because of distortion cost $\tau^T q^T$. The numbers for b^N can be interpreted similarly. The last three columns, which describe the benefits of de-dollarization, show that the insurance wedge $\Delta^w_{UIP} - \Delta^e_{UIP}$ that balances the terms $\mathcal{F}^\Delta$ and $\mathcal{R}^\Delta$ in optimum is equal to about 50*bp*.

One thing to notice is that the planner does not reduce debt up to the point where the constraint never binds and there is no Fisher amplification in optimum. The marginal costs of any intervention, like the UIP wedge in case of de-dollarization, are equal to zero at the unregulated equilibrium but catch up with marginal benefits before the uninternalized effects disappear. Marginal benefits decrease as the economy approaches the optimal portfolio but are still far from zero at the optimum.

Optimal taxes in this example are $\tau^T = 8.0\%$ and $\tau^N = 7.4\%$. This is lower than a naïve benchmark that would put them at the level of marginal benefits in the unregulated equilibrium, 10.8% and 9.8%, scaled by the relevant asset prices q^T and q^N. The reason is that the model exhibits a virtuous circle. When dollarization of savings falls, wages become less volatile, and their covariance with the exchange rate falls. This decreases demand for dollar as an insurance vehicle, making it easier to discourage saving in dollars on the margin.

Quantitatively, this is captured by marginal benefits of deleveraging, such as $\mathcal{F}^T + \mathcal{R}^T$, declining as the intervention progressively takes the economy from the unregulated state to the optimum. Consider raising the taxes gradually. At $\tau^T = 0$, marginal benefits of decreasing debt $\mathcal{F}^T + \mathcal{R}^T$ are high, but as taxes increase and relieve the economy of excess debt, $\mathcal{F}^T + \mathcal{R}^T$ falls. The planner stops raising taxes when they meet: $\tau^T = (\mathcal{F}^T + \mathcal{R}^T)/q^T$. In optimum, taxes are equal to the already decreased marginal benefits, appropriately scaled. The same applies to local currency debt.

Comparing the marginal benefits of de-dollarization to the marginal benefits of decreasing debt, we note that overborrowing is a problem in this example economy. Taxes on each type of debt are roughly ten times higher than the difference between them. However, the socially optimal portfolio is not much smaller than the unregulated one: $b^N + \mathbb{E}[p_1]b^T = 0.948$ in optimum against $b^N + \mathbb{E}[p_1]b^T = 0.967$ without taxes. The two allocations are really different in the level of dollarization (11% against 30%), but not in total indebtedness. This shows the importance of interactions between overborrowing and dollarization: in a less dollarized economy, the problem of overborrowing is less acute.

We can decompose changes in welfare into those coming from efficiency gains, redistribution, and risk-sharing. To this end, we compute counterfactual changes in workers' and entrepreneurs' values by replacing variables from the unregulated equilibrium with those from the social optimum one at a time. To calculate efficiency gains, we hold everything at the unregulated equilibrium and change the distribution of z to the one resulting in optimum. To calculate welfare changes from redistribution, we change the wage and exchange rate distributions to the socially optimal ones while keeping all else at the unregulated equilibrium. Finally, to calculate welfare changes from risk-sharing, we do the same with portfolios, asset prices, and taxes.

The value of the workers increases as the economy transitions to the optimum. About 116% of the increase is attributed to wages and 19% to the exchange rate since workers are net sellers of non-tradables. The losses from deteriorating risk-sharing contribute negatively and offset about a quarter of these gains. The value of entrepreneurs decreases, with about 115% of the decrease coming from higher wages and 18% from the exchange rate. Efficiency gains offset about a quarter of these losses, and losses from risk-sharing are small since entrepreneurs are risk-neutral. See Appendix E for details.

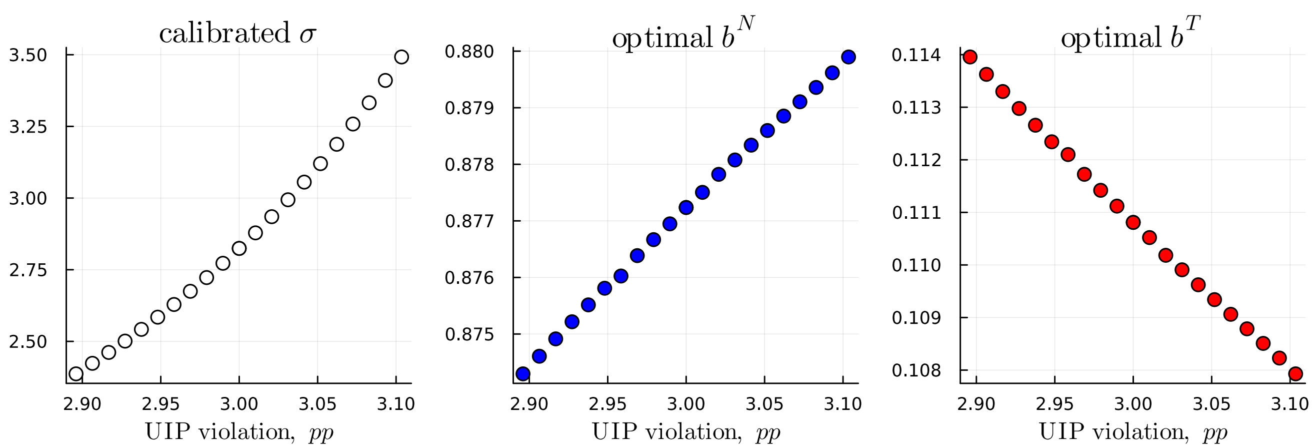
The fact that entrepreneurs' welfare decreases in the optimum means that it is not a Pareto improvement relative to the unregulated equilibrium. The reason is that pecuniary externalities are tightly related to redistribution in the model. Moving to the optimal portfolio benefits entrepreneurs through efficiency gains but also transfers their profits to workers through wages. The changing distribution of the exchange rate redistributes to workers as well.

It is still possible to find Pareto improvements relative to the unregulated equilibrium. We do this numerically. One such improvement maximizes workers' welfare subject to keeping entrepreneurs' value at its level before the intervention like in Bocola and Lorenzoni (2020b). Implementing this allocation redistributes wealth to workers through wages and exchange rates. To compensate entrepreneurs, the planner both decreases aggregate debt and increases portfolio dollarization. This makes borrowing cheaper for entrepreneurs since dollar debt commands a lower interest rate.

When the requirement to compensate entrepreneurs is relaxed, the planner would choose different points in the Pareto frontier depending on its weight on workers. We find that when this weight is higher, portfolio dollarization decreases to increase wages and remove the correlation between them and the exchange rate. Appendix F provides more details.

The role of the UIP deviation. We next investigate the connection between the magnitude of optimal de-dollarization and the UIP violation that the economy exhibits before intervention. In the simplified example at the end of Section 3 we showed that an observed violation of UIP may indicate the need for intervention in specific cases. In that example, however, we only considered local benefits of intervention around zero taxes. Globally, an observed violation of UIP may also indicate fundamental demand for insurance and justify high dollarization of savings in social optimum, even if benefits of de-dollarization are high on the margin in the unregulated economy.

Figure 3: Workers' risk-aversion and optimal savings as equilibrium UIP violation varies.



Our experiment suggests this to be the case. We re-calibrate the model to exhibit different deviations from UIP in equilibrium without taxes. Specifically, we fix the distributions of the traded endowments, real exchange rate at $t = 0$, and the price of the dollar-denominated debt q^T. We also hold constant the distribution of the real exchange rate at $t = 1$ given the baseline debt portfolio. We then vary $(\alpha, y^N, \beta_e, \sigma)$, the non-tradable share of expenditures and endowment, entrepreneurs' discount factor, and workers' risk-aversion. This changes the UIP deviation that arises in equilibrium. Changing σ allows us to change aversion to risk and hence demand for dollar assets for insurance purposes. Varying α, e^N, and β_e together allows us to fix p_0, q^T, and the distribution of p_1 conditional on baseline portfolio. This keeps the dollar interest rate and the exchange rate appreciation (given the baseline portfolio) constant across experiments.

Figure 3 shows that a higher dollar premium corresponds to a higher risk-aversion σ and a more dollarized portfolio in optimum. This example provides normative support to the logic of Christiano et al. (2021), who view internal dollarization as primarily driven by insurance needs.

5 Conclusion

We introduce dollarization of domestic flows into the analysis of macroprudential policy in emerging economies. This feature has received increasing attention in the literature, which has shown that domestic households finance local firms using instruments denominated in foreign currency. This observation is important for macroprudential policy, as limiting foreign currency borrowing by firms might increase households' financial exposure to exchange rate movements.

We set up a model in which internal dollarization arises naturally as non-financial income of savers declines when the exchange rate depreciates. We note that a premium on local currency instruments emerges if it is also costly for the entrepreneurs to repay debts in times of depreciation. This may be both because their income co-moves with the exchange rate and because they are risk averse. Another reason might be that their financial constraints tighten when currency depreciates. Our example at the end of Section 3 provides a word of caution when interpreting negative UIP deviations as a sign of the costs of de-dollarization. Policy should be concerned with decreasing debt payments in those states in which the value of the externalities is higher, and the tightness of borrowing constraints might signal strong externalities.

In a numerical example, we find that uninternalized costs of debt are higher than the taxes required to implement the optimal allocation. The reason is that savers' demand for insurance falls when the economy becomes less fragile, making de-dollarization progressively easier to incentivize when the economy moves to the social optimum. We interpret this as a virtuous circle.

The model could be extended to incorporate several ingredients. First, it does not have a financial sector and savers deal directly with borrowing firms. A useful next step in studying the same macroprudential policy trade-offs could be to incorporate intermediaries. The nature of their constraints and the effects of currency and maturity mismatch might be very different from those in our model, leading to different policy implications. Another element that our model does not consider is the broader exchange rate and monetary policy regimes. As is well known, the central bank is not always able to act as a lender of last resort in a dollarized financial system since it does not always have access to swap lines or sufficient hard currency reserves. This consideration could add to the benefits of de-dollarization in a richer model.

References

Alam, Z., Alter, A., Eiseman, J., Gelos, G., Kang, H., Narita, M., Nier, E., and Wang, N. (2019). Digging Deeper – Evidence on the Effects of Macroprudential Policies from a New Database. Technical report, IMF.

Arellano, C. and Mendoza, E. G. (2002). Credit frictions and'sudden stops' in small open economies: An equilibrium business cycle framework for emerging markets crises.

Benigno, G., Chen, H., Otrok, C., Rebucci, A., and Young, E. R. (2013). Financial crises and macro-prudential policies. Journal of International Economics, 89(2):453–470.

Bianchi, J. (2011). Overborrowing and systemic externalities in the business cycle. American Economic Review, 101(7):3400–3426.

Bianchi, J., Liu, C., and Mendoza, E. G. (2016). Fundamentals news, global liquidity and macroprudential policy. Journal of International Economics, 99:S2–S15.

Bianchi, J. and Mendoza, E. G. (2018). Optimal time-consistent macroprudential policy. Journal of Political Economy, 126(2):588–634.

Bianchi, J. and Mendoza, E. G. (2020). A fisherian approach to financial crises: Lessons from the sudden stops literature. Review of Economic Dynamics, 37:S254–S283.

Biljanovska, N. and Vardoulakis, A. (2022). Suddens stops and optimal policy in a two-agent economy. Technical report.

Bocola, L. and Lorenzoni, G. (2020a). Financial crises, dollarization, and lending of last resort in open economies. American Economic Review, 110(8):2524–57.

Bocola, L. and Lorenzoni, G. (2020b). Risk sharing externalities. Working Paper 26985, National Bureau of Economic Research.

Chen, X., Favilukis, J., and Ludvigson, S. C. (2013). An estimation of economic models with recursive preferences. Quantitative Economics, 4(1):39–83.

Christiano, L., Dalgic, H., and Nurbekyan, A. (2021). Financial dollarization in emerging markets: Efficient risk sharing or prescription for disaster? Working Paper 29034, National Bureau of Economic Research.

Dalgic, H. (2020). Financial dollarization in emerging markets: An insurance mechanism.

Dalgic, H. C. (2018). Financial dollarization in emerging markets: An insurance arrangement. University of Mannheim, 248.

Drenik, A., Pereira, G., and Perez, D. J. (2018). Wealth redistribution after exchange rate devaluations. In AEA Papers and Proceedings, volume 108, pages 552–56.

Epstein, L. G. and Zin, S. E. (1991). Substitution, risk aversion, and the temporal behavior of consumption and asset returns: An empirical analysis. Journal of political Economy, 99(2):263–286.

Farhi, E. and Werning, I. (2012). Dealing with the Trilemma: Optimal Capital Controls with Fixed Exchange Rates. NBER Working Papers 18199, National Bureau of Economic Research, Inc.

Farhi, E. and Werning, I. (2016). A theory of macroprudential policies in the presence of nominal rigidities. Econometrica, 84(5):1645–1704.

Gutierrez, B., Ivashina, V., and Salomao, J. (2021). Why is dollar debt cheaper? evidence from peru. Technical report, SSRN.

Korinek, A. (2011). The new economics of prudential capital controls: A research agenda. IMF Economic Review, 59(3):523–561.

Korinek, A. (2018). Regulating capital flows to emerging markets: An externality view. Journal of International Economics, 111:61–80.

Korinek, A. and Sandri, D. (2016). Capital controls or macroprudential regulation? Journal of International Economics, 99:S27–S42.

Krugman, P. (1999). Balance sheets, the transfer problem, and financial crises. International Tax and Public Finance, 6:459–472.

Liu, S., Ma, C., and Shen, H. (2021). Sudden stop with local currency debt. Available at SSRN 3785755.

Lorenzoni, G. (2008). Inefficient Credit Booms. The Review of Economic Studies, 75(3):809–833.

Mendoza, E. G. (2002). Credit, Prices, and Crashes: Business Cycles with a Sudden Stop, pages 335–392. University of Chicago Press.

Mendoza, E. G. and Rojas, E. (2019). Positive and normative implications of liability dollarization for sudden stops models of macroprudential policy. IMF Economic Review, 67(1):174–214.

A Proofs

Proof. (of Proposition 1) Using the definition of $\mathcal{W}(b^T, b^N)$,

$$\mathcal{W} = \max\ \phi \left((C_0^w)^{1-\zeta} + \beta_w \mathbb{E}[(C_1^w)^{1-\sigma}]^{\frac{1-\zeta}{1-\sigma}} \right) + (1-\phi) \left((C_0^e)^{1-\zeta_e} + \beta_e \mathbb{E}[(C_1^e)^{1-\sigma_e}]^{\frac{1-\zeta_e}{1-\sigma_e}} \right) \tag{58}$$

$$\text{s.t. } p_0^\alpha C_0^w = e_0^{w,T} + p_0 e_0^{N,w} - p_0 q^N b^N - q^T b^T \tag{59}$$

$$p_0^\alpha C_0^e = e_0^{e,T} + p_0 e_0^{e,N} + p_0 q^N b^N + q^T b^T + \tilde{q}\tilde{b} \tag{60}$$

$$p_1^\alpha C_1^w = e_1^{w,T} + p_1 e_1^{w,N} + w_1 l + b^T + p_1 b^N \tag{61}$$

$$p_1^\alpha C_1^e = e_1^{e,T} + p_1 e_1^{e,N} + f(z_1, l) - w_1 l - z_1 - b^T - p_1 b^N - \tilde{b} \tag{62}$$

$$q^T = \beta_w \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha} \frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}} \right] \mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}} \right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{63}$$

$$q^N = \beta_w \mathbb{E}\left[\frac{p_0^{1-\alpha}}{p_1^{1-\alpha}} \frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}} \right] \mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}} \right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{64}$$

$$(1-\tau^T) q^T = \beta_e \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha} \frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}} \cdot (1 + \theta^{-1}\delta_1(f_z(z_1, l) - 1)) \right] \mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}} \right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{65}$$

$$(1-\tau^N) q^N = \beta_e \mathbb{E}\left[\frac{p_0^{1-\alpha}}{p_1^{1-\alpha}} \frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}} \cdot (1 + \theta^{-1}\delta_1(f_z(z_1, l) - 1)) \right] \mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}} \right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{66}$$

$$(1-\tau^T) q^T = (1-\tilde{\tau})\tilde{q} \tag{67}$$

$$p_1 = \frac{\alpha}{1-\alpha} \frac{f(z_1, l) - z_1 + e_1^{w,T} + e_1^{e,T} - \tilde{b}}{e_1^{w,N} + e_1^{e,N}} \tag{68}$$

$$z_1 = \min\left\{ \bar{z}, \theta^{-1}(p_1(\bar{b} - b^N) - b^T - \tilde{b}) \right\} \tag{69}$$

$$w_1 = f_l(z_1, l) \tag{70}$$

Maximization is over $\{C_0^w, C_0^e, q^T, q^N, \tau^T, \tau^N, \tilde{\tau}\}$ and $\{C_1^w, C_1^e, p_1, z_1, w_1\}$ for any realization of the traded endowments $\epsilon = (e_1^{w,T}, e_1^{e,T})$. Let the multipliers on the budget constraints (59), (60), (61), and (62) be λ_0^w, λ_0^e, λ_1^w, and λ_1^e. Let the multipliers on the asset price constraints (63), (64), (65), and (66) be $\mu^{T,w}$, $\mu^{N,w}$, $\mu^{T,e}$, and $\mu^{N,e}$. Finally, denote the functions in the right-hand side of (63), (64), (65), and (66) by $Q^{T,w}$, $Q^{N,w}$, $Q^{T,e}$, and $Q^{N,e}$.

Notice that the taxes $(\tau^T, \tau^N, \tilde{\tau})$ can be set residually so that the constraints in (65), (66), and (67) are always satisfied. The multipliers on these constraints are hence zero. In particular, $\mu^{T,e} = \mu^{N,e} = 0$. Taking the derivatives with respect to C_0^w, C_0^e, C_1^w, and C_1^e (the latter two variables really mean their realizations in every state of the shock ϵ),

$$\phi(1-\zeta)(C_0^w)^{-\zeta} = p_0^\alpha \lambda_0^w + \mu^{T,w}\frac{\partial Q^{T,w}}{\partial C_0^w} + \mu^{N,w}\frac{\partial Q^{N,w}}{\partial C_0^w} \tag{71}$$

$$(1-\phi)(1-\zeta_e)(C_0^e)^{-\zeta_e} = p_0^\alpha \lambda_0^e \tag{72}$$

$$\pi_1(\epsilon)\cdot\beta^w\phi(1-\zeta)C_1^w(\epsilon)^{-\sigma}\mathbb{E}\left[C_1^w(\epsilon)^{1-\sigma}\right]^{\frac{\sigma-\zeta}{1-\sigma}} = p_1^\alpha\lambda_1^w(\epsilon) + \mu^{T,w}\frac{\partial Q^{T,w}}{\partial C_1^w(\epsilon)} + \mu^{N,w}\frac{\partial Q^{N,w}}{\partial C_1^w(\epsilon)} \tag{73}$$

$$\pi_1(\epsilon)\cdot\beta^e(1-\phi)(1-\zeta_e)C_1^e(\epsilon)^{-\sigma_e}\mathbb{E}\left[C_1^e(\epsilon)^{1-\sigma_e}\right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} = p_1^\alpha\lambda_1^e(\epsilon) \tag{74}$$

Here $\pi_1(\epsilon)$ is the probability of the realization ϵ. Taking the derivatives with respect to q^T and q^N,

$$\mu^{T,w} = b^T(\lambda_0^w - \lambda_0^e) \tag{75}$$

$$\mu^{N,w} = p_0 b^N(\lambda_0^w - \lambda_0^e) \tag{76}$$

Changes in these prices have a purely redistributive effect. Combining these equations with (71) and (72) and using the assumption that the weights satisfy $\phi(1-\zeta)(C_0^w)^{-\zeta} = (1-\phi)(1-\zeta_e)(C_0^w)^{-\zeta_e}$,

$$\begin{aligned} 0 &= (\lambda_0^w - \lambda_0^e)\left(p_0^\alpha + b^T\frac{\partial Q^{T,w}}{\partial C_0^w} + p_0 b^N\frac{\partial Q^{N,w}}{\partial C_0^w}\right) \\ &= (\lambda_0^w - \lambda_0^e)\frac{p_0^\alpha C_0^w + \zeta(q^T b^T + p_0 b^N q^N)}{C_0^w} \end{aligned} \tag{77}$$

The numerator of the fraction is not zero. If $q^T b^T + p_0 b^N q^N \geq 0$ then it is positive, and if $q^T b^T + p_0 b^N q^N < 0$, then

$$p_0^\alpha C_0^w + \zeta(q^T b^T + p_0 b^N q^N) > p_0^\alpha C_0^w + q^T b^T + p_0 b^N q^N = e_0^{T,w} + p_0 e_0^{N,w} > 0 \tag{78}$$

This implies $\lambda_0^w = \lambda_0^e$, meaning that, to the planner, the marginal value of additional dollar allocated to an agent is the same across agents. From (75) and (76) this implies that $\mu^{T,w} = \mu^{N,w} = 0$. Then, using the definitions in the text of the proposition, $\pi_1(\epsilon)\Lambda^e(\epsilon) = \lambda_1^w(\epsilon)/\lambda_0^w$, $\pi_1(\epsilon)\Lambda^e(\epsilon) = \lambda_1^e(\epsilon)/\lambda_0^e$, and $\mathcal{U}_0 = \lambda_0^w = \lambda_0^e$.

Next, denote by $Z(b^T, b^N, \epsilon)$, $P(z_1, \epsilon)$, and $W(z_1)$ the solution of the system of (68), (69), and (70), where z_1 is expressed as a function of the shock ϵ and debt (b^T, b^N), p_1 is expressed as a function of z_1 and ϵ, and w_1 as a function of z_1. By the envelope theorem, the derivatives of $\mathcal{W}(b^T, b^N)$ are

$$\begin{aligned} \frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^T} &= \mathbb{E}\left[\frac{\partial P}{\partial z_1}\cdot\frac{\partial Z}{\partial b^T}\left(\Lambda^w(b^N + e_1^{N,w} - \alpha p_1^{\alpha-1}C_1^w) + \Lambda^e(e_1^{N,e} - b^N - \alpha p_1^{\alpha-1}C_1^e)\right)\right] \\ &\quad + \mathbb{E}\left[\frac{\partial W}{\partial z_1}l\cdot\frac{\partial Z}{\partial b^T}(\Lambda^w - \Lambda^e)\right] + \mathbb{E}\left[\frac{\partial Z}{\partial b^T}\Lambda^e(f_z(z_1,l)-1)\right] + \mathbb{E}[\Lambda^w - \Lambda^e] \end{aligned} \tag{79}$$

$$\begin{aligned} \frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^N} &= \mathbb{E}\left[\frac{\partial P}{\partial z_1}\cdot\frac{\partial Z}{\partial b^N}\left(\Lambda^w(b^N + e_1^{N,w} - \alpha p_1^{\alpha-1}C_1^w) + \Lambda^e(e_1^{N,e} - b^N - \alpha p_1^{\alpha-1}C_1^e)\right)\right] \\ &\quad + \mathbb{E}\left[\frac{\partial W}{\partial z_1}l\cdot\frac{\partial Z}{\partial b^N}(\Lambda^w - \Lambda^e)\right] + \mathbb{E}\left[\frac{\partial Z}{\partial b^N}\Lambda^e(f_z(z_1,l)-1)\right] + \mathbb{E}[p_1\cdot(\Lambda^w - \Lambda^e)] \end{aligned} \tag{80}$$

Using the fact that $\alpha p_1^\alpha C_1^w = p_1 c_1^{N,w}$, $\alpha p_1^\alpha C_1^e = p_1 c_1^{N,e}$, and $c_1^{N,w} + c_1^{T,w} = e_1^{N,w} + e_1^{T,w}$,

$$\begin{aligned} \frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^T} &= \mathbb{E}\left[(\Lambda^w - \Lambda^e)\mathcal{Z}_1\mathcal{D}_1^p m_1^w\right] + \mathbb{E}\left[(\Lambda^w - \Lambda^e)\mathcal{Z}_1\mathcal{D}_1^w l\right] \\ &+ \mathbb{E}\left[\Lambda^e\mathcal{Z}_1(f_z(z_1,l)-1)\right] + \mathbb{E}[\Lambda^w - \Lambda^e] \qquad (81) \\ \frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^N} &= \mathbb{E}\left[p_1\cdot(\Lambda^w - \Lambda^e)\mathcal{Z}_1\mathcal{D}_1^p m_1^w\right] + \mathbb{E}\left[p_1\cdot(\Lambda^w - \Lambda^e)\mathcal{Z}_1\mathcal{D}_1^w l\right] \\ &+ \mathbb{E}\left[p_1\cdot\Lambda^e\mathcal{Z}_1(f_z(z_1,l)-1)\right] + \mathbb{E}[p_1\cdot(\Lambda^w - \Lambda^e)] \qquad (82) \end{aligned}$$

Here $m_1^w = b^N + e_1^{N,w} - c_1^{N,w}$ and $(\mathcal{Z}_1, \mathcal{D}_1^w, \mathcal{D}_1^p)$ is the notation for the derivatives of (Z, W, P).

Now recall that

$$q^T = \mathbb{E}[\Lambda^w] \qquad (83)$$

$$q^N = \mathbb{E}[p_1\Lambda^w] \qquad (84)$$

$$(1-\tau^T)q^T = \mathbb{E}[\Lambda^e(1+\delta_1\theta^{-1}(f_z(z_1,l)-1))] \qquad (85)$$

$$(1-\tau^N)q^N = \mathbb{E}[p_1\Lambda^e(1+\delta_1\theta^{-1}(f_z(z_1,l)-1))] \qquad (86)$$

Plugging these,

$$\frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^T} = \mathbb{E}\left[(\Lambda^w - \Lambda^e)(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\mathcal{Z}_1\right] + \mathbb{E}\left[\Lambda^e(\mathcal{Z}_1 + \delta_1\theta^{-1})(f_z(z_1,l)-1)\right] + \tau^T q^T \qquad (87)$$

$$\begin{aligned} \frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^N} &= \mathbb{E}\left[p_1\cdot(\Lambda^w - \Lambda^e)(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\mathcal{Z}_1\right] + \mathbb{E}\left[p_1\cdot\Lambda^e(\mathcal{Z}_1 + \delta_1\theta^{-1})(f_z(z_1,l)-1)\right] \\ &+ \tau^N q^N p_0 \qquad (88) \end{aligned}$$

This completes the proof. □

Proof. (of Proposition 2) Using Proposition 1 and denoting $s_1 = p_1/p_0$,

$$\begin{aligned} \frac{1}{p_0\mathcal{U}_0}\left(\frac{\partial \mathcal{W}}{\partial b^N} - \mathbb{E}[p_1]\frac{\partial \mathcal{W}}{\partial b^T}\right) &= \mathbb{E}\left[s_1\cdot(\Lambda^w - \Lambda^e)(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\mathcal{Z}_1\right] \\ &- \mathbb{E}[s_1]\cdot\mathbb{E}\left[(\Lambda^w - \Lambda^e)(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\mathcal{Z}_1\right] \\ &+ \mathbb{E}\left[s_1\cdot\Lambda^e(\mathcal{Z}_1 + \delta_1\theta^{-1})(f_z(z_1,l)-1)\right] \\ &- \mathbb{E}[s_1]\cdot\mathbb{E}\left[\Lambda^e(\mathcal{Z}_1 + \delta_1\theta^{-1})(f_z(z_1,l)-1)\right] \\ &+ (q^N - (1-\tau^N)q^N) - (q^T - (1-\tau^T)q^T)\mathbb{E}[s_1] \\ &= \mathbb{C}\left[s_1, (\Lambda^w - \Lambda^e)(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\mathcal{Z}_1\right] \\ &+ \mathbb{C}\left[s_1, \Lambda^e(\mathcal{Z}_1 + \delta_1\theta^{-1})(f_z(z_1,l)-1)\right] \\ &- (q^T\mathbb{E}[s_1] - q^N) + ((1-\tau^T)q^T\mathbb{E}[s_1] - (1-\tau^N)q^N) \qquad (89) \end{aligned}$$

Using the definitions of the UIP violations $\Delta^w_{UIP} = q^T\mathbb{E}[s_1] - q^N$ and $\Delta^e_{UIP} = (1-\tau^T)q^T\mathbb{E}[s_1] - (1-\tau^N)q^N$ leads to the result in the proposition. □

Proof. (of Corollary 1) This corollary follows directly from Proposition 1 when the derivatives of $\mathcal{W}(b^T, b^N)$ are set to zero. □

B Alternative setups

In this section, we discuss extensions of the model that incorporate foreign savings, alternative specifications of the borrowing constraint, capital controls, and an alternative specification of taxes.

B.1 Foreign savings

Suppose that workers are allowed to buy claims to traded goods abroad. Denote their holdings by $\tilde{B}$. Suppose that they buy these claims at the same price $\tilde{q}$ at which entrepreneurs borrow from abroad. The problem of the workers becomes

$$\mathcal{V}^w = \max \ \mathcal{C}\left(c_0^{N,w}, c_0^{T,w}\right)^{1-\zeta} + \beta_w \mathbb{E}\left[\mathcal{C}\left(c_1^{N,w}, c_1^{T,w}\right)^{1-\sigma}\right]^{\frac{1-\zeta}{1-\sigma}} \tag{90}$$

$$\text{s.t. } p_0 c_0^{N,w} + c_0^{T,w} + q^T b^T + \tilde{q}\tilde{B} + p_0 q^N b^N \leq w_0 l_0 + e_0^{T,w} + p_0 e_0^{N,w} \tag{91}$$

$$p_1 c_1^{N,w} + c_1^{T,w} \leq w_1 l_1 + e_1^{T,w} + p_1 e_1^{N,w} + b^T + \tilde{B} + p_1 b^N \tag{92}$$

The balance of payments identity changes to

$$c_0^{T,w} + c_0^{T,e} = f(z_0, l_0) - z_0 + e_0^{T,w} + e_0^{T,e} + \tilde{q}(\tilde{b} - \tilde{B})$$
$$c_1^{T,w} + c_1^{T,e} = f(z_1, l_1) - z_1 + e_1^{T,w} + e_1^{T,e} - (\tilde{b} - \tilde{B})$$

This means that the equilibrium exchange rate is given by

$$p_0 = \frac{\alpha}{1-\alpha} \cdot \frac{c_0^{T,w} + c_0^{T,e}}{c_0^{N,w} + c_0^{N,e}} = \frac{\alpha}{1-\alpha} \cdot \frac{f(z_0, l_0) - z_0 + e_0^{T,w} + e_0^{T,e} + \tilde{q}(\tilde{b} - \tilde{B})}{e_0^{N,w} + e_0^{N,e}} \tag{93}$$

$$p_1 = \frac{\alpha}{1-\alpha} \cdot \frac{c_1^{T,w} + c_1^{T,e}}{c_1^{N,w} + c_1^{N,e}} = \frac{\alpha}{1-\alpha} \cdot \frac{f(z_1, l_1) - z_1 + e_1^{T,w} + e_1^{T,e} + (\tilde{B} - \tilde{b})}{e_1^{N,w} + e_1^{N,e}} \tag{94}$$

Suppose that, on the supply side, the price of the cross-border claims only depends on the net flows, $\tilde{q} = Q(\tilde{b} - \tilde{B})$, and that there are no taxes.

Observe that, for any $x \in [0, \tilde{B}]$, an equilibrium of this model with $(b^T, \tilde{b}, \tilde{B})$ is equivalent to an equilibrium with $(b^T + x, \tilde{b} - x, \tilde{B} - x)$. The budget constraints across the two equilibria are the same, since workers save $b^T + \tilde{B}$ and entrepreneurs borrow $\tilde{b}$ in foreign currency in both cases. The expression for the exchange rate are identical across the two cases. Finally, the borrowing constraint of the entrepreneurs is the same in the two allocations, since it only features the total amount borrowed in foreign currency. In the extreme case $x = \tilde{B}$, workers do not save abroad like in the baseline model.

The upshot is that we can restrict savings abroad to be zero without loss of generality provided that the foreign interest rate only depends on the net foreign asset position. Marginal effects $\mathcal{D}_1^p$, $\mathcal{D}_1^w$, and $\mathcal{Z}_1$ are also the same as in the baseline model. This means that the results from Section 3 can be extended to this richer version upon using a suitable tax system. Specifically, the planner would need to impose the same capital control tax $\tilde{\tau}$ on the savers and reimburse the proceeds $\tilde{\tau}\tilde{q}\tilde{B}$ to them. This insures that both savers and borrowers are indifferent between domestic and cross-border foreign currency flow, and the NFA remains fixed throughout the exercise.

B.2 Alternative borrowing constraints

Wage bill in the constraint. Consider the following modification to the entrepreneur's problem:

$$\mathcal{V}^e = \max\ \mathcal{C}(c_0^{e,N}, c_0^{e,T})^{1-\zeta_e} + \beta_e \mathbb{E}[\mathcal{C}(c_1^{e,N}, c_1^{e,T})^{1-\sigma_e}]^{\frac{1-\zeta_e}{1-\sigma_e}} \tag{95}$$

$$\text{s.t. } p_0 c_0^{N,e} + c_0^{T,e} \le f(z_0, l_0) - w_0 l_0 - z_0 + y_0^{T,e} + p_0 y_0^{N,e} \tag{96}$$
$$+ (1-\tilde{\tau})\tilde{q}\tilde{b} + (1-\tau^T) q^T b^T + (1-\tau^N) p_0 q^N b^N + T$$

$$p_1 c_1^{N,e} + c_1^{T,e} + \tilde{b} + b^T + p_1 b^N \le f(z_1, l_1) - w_1 l_1 - z_1 + y_1^{T,e} + p_1 y_1^{N,e} \tag{97}$$

$$\theta_z z_1 + \theta_l w_1 l_1 \le p_1\left(\bar{b} - b^N\right) - b^T - \tilde{b} \tag{98}$$

The new element here is the portion $\theta_l w_1 l_1$ of the wage bill that has to be pre-funded alongside the portion of tradable inputs $\theta_z z_1$. Assume first $\theta_z > 0$ and $\theta_l > 0$. The first-order conditions with respect to l_1 and z_1 are modified to

$$f_z(z_1, l_1) = 1 + \mu\theta_z \tag{99}$$

$$f_l(z_1, l_1) = w_1(1 + \mu\theta_l) \tag{100}$$

Here μ is the Lagrange multiplier on (98). Since labor is supplied inelastically at l, adjustment in (100) happens through w_1. Wages are now directly impacted by debt through the borrowing constraint in addition to the effect through z_1. We can express the wage as

$$w_1 = \frac{\theta_z f_l(z_1, l)}{\theta_z + \theta_l(f_z(z_1, l) - 1)} \tag{101}$$

The borrowing constraint can be rewritten as

$$\theta_z\left(z_1 + \frac{\theta_l f_l(z_1, l) l}{\theta_z + \theta_l(f_z(z_1, l) - 1)}\right) \le p_1\left(\bar{b} - b^N\right) - b^T - \tilde{b} \tag{102}$$

The market-clearing condition for the non-traded good, and hence the expression for the exchange rate, does not change. The planner's problem can still be solved as in the baseline version of the model: isolating $z_1 = Z(b^T, b^N, \epsilon)$, $p_1 = P(Z(b^T, b^N, \epsilon), \epsilon)$, and $w_1 = W(Z(b^T, b^N, \epsilon))$, then computing marginal effects of debt. The marginal effect of z_1 on p_1 is the same as before:

$$\mathcal{D}_1^p = \frac{\alpha}{(1-\alpha)y_1^N} \cdot (f_z(z_1, l) - 1) \tag{103}$$

The marginal effects on the wage and input use now take a more involved form:

$$\mathcal{D}_1^w = \frac{\theta_z f_{zl}(z_1, l)(\theta_z + \theta_l(f_z(z_1, l) - 1)) - \theta_z \theta_l f_l(z_1, l) f_{zz}(z_1, l)}{(\theta_z + \theta_l(f_z(z_1, l) - 1))^2} \tag{104}$$

$$\mathcal{Z}_1 = -\frac{\delta_1}{\theta_z + \delta_1\theta_l\mathcal{D}_1^w - \delta_1\mathcal{D}_1^p\left(\bar{b} - b^N\right)} \tag{105}$$

In the denominator of $\mathcal{Z}_1$, there is now an additional positive term $\delta_1\theta_l\mathcal{D}_1^w$ that attenuates the magnitude of $\mathcal{Z}_1$. When the borrowing constraint becomes binding in this setup, part of the adjustment happens trough w_1 and less through z_1. The expressions for the marginal benefits of increasing debt and de-dollarization remain the same up to these changes in $\mathcal{D}_1^w$ and $\mathcal{Z}_1$.

Now assume $\theta_l > 0$ but $\theta_z = 0$. In this case, (99) means that $f_z(z_1, l) = 1$ for any realization of the shock ϵ and any debt level. The exchange rate is hence determined by ϵ only. There is no amplification through the exchange rate and no uninternalized effects besides those on wages. The derivatives of the wage with respect to b^T and b^N have to be computed directly:

$$\frac{dw_1}{db^T} = -\frac{1}{\theta_l l} \tag{106}$$

$$\frac{dw_1}{db^N} = -\frac{p_1}{\theta_l l} \tag{107}$$

This is the only effect that the planner takes into account and the agents do not. The benefits of increasing debt and de-dollarizing the portfolio now only come from the wage bill and are purely redistributive. Analogously to Proposition 1 and Proposition 2, we can express them as

$$\frac{1}{\mathcal{U}_0}\frac{d\mathcal{W}}{db^T} = -\frac{1}{\theta_l l}\mathbb{E}[\Lambda^w - \Lambda^e] + \tau^T q^T \tag{108}$$

$$\frac{1}{\mathcal{U}_0}\frac{d\mathcal{W}}{db^T} = -\frac{1}{\theta_l l}\mathbb{E}[p_1(\Lambda^w - \Lambda^e)] + p_0 \tau^N q^N \tag{109}$$

$$\Delta = \frac{1}{\theta_l l}\mathbb{C}\left[\Lambda^w - \Lambda^e, \frac{p_1}{p_0}\right] - (\Delta^w_{UIP} - \Delta^e_{UIP}) \tag{110}$$

From the workers' perspective, gains from de-dollarization come from making the constraint on wages less tight in times of depreciation, which decreases the correlation between wages and the exchange rate. This is a benefit if depreciation is associated with a high marginal utility Λ^w. For entrepreneurs, it is the opposite because they pay wages rather than receive them.

Revenue in the borrowing constraint. Suppose now a part of revenue $\theta_f f(z_1, l_1)$ for $\theta_f < \theta_z$ could be pledged as collateral. The borrowing constraint changes to

$$\theta_z z_1 \le \theta_f f(z_1, l_1) + p_1\left(\bar{b} - b^N\right) - b^T - \tilde{b} \tag{111}$$

The first-order conditions with respect to z_1 and l_1 are modified to

$$f_z(z_1, l_1)(1 + \mu\theta_f) = 1 + \mu\theta_z \tag{112}$$

$$f_l(z_1, l_1)(1 + \mu\theta_f) = w_1 \tag{113}$$

Rearranging and plugging $l_1 = l$,

$$w_1 = f_l(z_1, l)\frac{\theta_z + \theta_f}{\theta_z - \theta_f f_z(z_1, l)} \tag{114}$$

We can again solve the planner's problem by isolating $z_1 = Z(b^T, b^N, \epsilon)$, $p_1 = P(Z(b^T, b^N, \epsilon), \epsilon)$, and $w_1 = W(Z(b^T, b^N, \epsilon))$, and then computing marginal effects of debt. The marginal effect of z_1 on p_1 does not change. The marginal effect of z_1 on w_1 changes to

$$\mathcal{D}_1^w = \frac{(\theta_z + \theta_f)(f_{zl}(z_1, l)(\theta_z - \theta_f f_z(z_1, l)) + f_l(z_1, l) f_{zz}(z_1, l)\theta_f)}{(\theta_z - \theta_f f_z(z_1, l))^2} \tag{115}$$

The marginal effect of debt on z_1 changes to

$$\mathcal{Z}_1 = -\frac{\delta_1}{\theta_z - \delta_1 f_z(z_1, l) - \delta_1 \mathcal{D}_1^p\big(\bar{b} - b^N\big)} \tag{116}$$

There is a negative term $-\delta_1 f_z(z_1, l)$ in the denominator that is new relative to the baseline. Additional amplification comes from the fact that lower input use tightens the borrowing constraint by reducing pledgeable revenue. The expressions for the marginal benefits of increasing debt and de-dollarization remain the same up to the changes in $\mathcal{D}_1^w$ and $\mathcal{Z}_1$ above.

B.3 Varying cross-border debt $\tilde{b}$

The function $\mathcal{W}(b^T, b^N)$ takes $\tilde{b}$ as a fixed parameter. Using the envelope theorem, we can describe the impact of $\tilde{b}$ on welfare by taking the derivative analogous to the ones in Proposition 1.

To do this, we first need to see how (p_1, z_1, w_1) depend on $\tilde{b}$ when the system of (31), (32), and (33) is solved to produce the functions $p_1 = \tilde{P}(z_1, \tilde{b}, \epsilon)$, $z_1 = \tilde{Z}(b^T, b^N, \tilde{b}, \epsilon)$, and $w_1 = W(z_1)$. The difference between $P(\cdot)$ and $\tilde{P}(\cdot)$ is that the latter incorporates $\tilde{b}$ as a variables as it acknowledges the direct effect of $\tilde{b}$ on p_1 through the numerator of the right-hand side:

$$p_1 = \frac{\alpha}{1-\alpha} \frac{f(z_1, l) - z_1 + e_1^{w,T} + e_1^{e,T} - \tilde{b}}{e_1^{w,N} + e_1^{e,N}} \tag{117}$$

Similarly, the difference between $Z(\cdot)$ and $\tilde{Z}(\cdot)$ is that the latter incorporates $\tilde{b}$ as an argument in

$$z_1 = \min\left\{\bar{z}, \theta^{-1}(p_1(\bar{b} - b^N) - b^T - \tilde{b})\right\} \tag{118}$$

Accordingly, the marginal effect of $\tilde{b}$ incorporates the partial derivative of $\tilde{P}(\cdot)$ with respect to $\tilde{b}$:

$$\begin{aligned} \tilde{\mathcal{Z}}_1 = \frac{d\tilde{Z}}{d\tilde{b}} &= \frac{d\tilde{P}}{d\tilde{b}}\theta^{-1}\delta_1(\bar{b} - b^N) - \theta^{-1}\delta_1 = \left(\mathcal{D}_1^p \tilde{\mathcal{Z}}_1 + \frac{\partial \tilde{P}}{\partial \tilde{b}}\right)\theta^{-1}\delta_1(\bar{b} - b^N) - \theta^{-1}\delta_1 \\ &= \frac{\delta_1}{\theta - \mathcal{D}_1^p \delta_1(\bar{b} - b^N)}\left(\frac{\partial \tilde{P}}{\partial \tilde{b}}(\bar{b} - b^N) - 1\right) = -\frac{\delta_1(1 + \tilde{\Delta}(\bar{b} - b^N))}{\theta - \mathcal{D}_1^p \delta_1(\bar{b} - b^N)} \end{aligned} \tag{119}$$

Here $\tilde{\Delta}$ is given by

$$\tilde{\Delta} = -\frac{\partial \tilde{P}}{\partial \tilde{b}} = \frac{\alpha}{(1-\alpha)(e_1^{N,w} + e_1^{N,e})} \tag{120}$$

We can now take the derivative of $\mathcal{W}$, going through all the steps in the proof of Proposition 1:

$$\begin{aligned} \frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial \tilde{b}} &= \mathbb{E}\left[(\Lambda^w - \Lambda^e)\left(\frac{\partial \tilde{P}}{\partial z_1}\frac{d\tilde{Z}}{d\tilde{b}} + \frac{\partial \tilde{P}}{\partial \tilde{b}}\right)m_1^w\right] + \mathbb{E}\left[(\Lambda^w - \Lambda^e)\frac{d\tilde{Z}}{d\tilde{b}}\frac{\partial W}{\partial z_1}l\right] \\ &\quad + \mathbb{E}\left[\frac{d\tilde{Z}}{d\tilde{b}}\Lambda^e(f_z(z_1, l) - 1)\right] + \tilde{q} + Q'(\tilde{b})\tilde{b} - \mathbb{E}[\Lambda^e] \end{aligned} \tag{121}$$

Here $Q'(\tilde{b})\tilde{b}$ reflects the fact that the interest rate on foreign loans changes because their supply is not perfectly elastic. Note that changing $\tilde{b}$ also changes p_0, the exchange rate at $t = 0$. This effect does not appear in the welfare calculation because it only redistributes through a revaluation of non-tradables at $t = 0$, and the weight ϕ makes this redistribution contribute exactly zero to $\mathcal{W}$ on the margin.

The private first-order condition of the entrepreneurs with respect to $\tilde{b}$ is

$$(1-\tilde{\tau})\tilde{q} = \mathbb{E}[\Lambda^e(1+\theta^{-1}(f_z(z_1,l)-1))] \tag{122}$$

Plugging this and using the notation for the marginal effects,

$$\begin{aligned}\frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial \tilde{b}} &= \mathbb{E}\left[(\Lambda^w-\Lambda^e)(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\tilde{\mathcal{Z}}_1\right] + \mathbb{E}\left[\Lambda^e(\tilde{\mathcal{Z}}_1 + \delta_1\theta^{-1})(f_z(z_1,l)-1)\right] + \tilde{\tau}\tilde{q} \\ &\quad + Q'(\tilde{b})\tilde{b} - \mathbb{E}\left[(\Lambda^w-\Lambda^e)\tilde{\Delta} m_1^w\right]\end{aligned} \tag{123}$$

There are three differences between (123) and (38), its analog for b^T. First, the marginal effect of $\tilde{b}$ on z_1 is stronger than that of b^T. This is because $\tilde{b}$ has a direct effect on the exchange rate. A higher $\tilde{b}$ lowers the exchange rate and puts additional pressure on z_1 through the borrowing constraint. Second, the last term in (123) captures the redistributive consequences of this direct effect of $\tilde{b}$ on p_1. A change in the exchange rate leads to a revaluation of the non-traded endowments. This term reflects the planner's incentives to manage the exchange rate by choosing the net foreign asset position, akin to those in Farhi and Werning (2012) and Farhi and Werning (2016). Third, the planner realizes that foreign supply of loans is not perfectly elastic, and the price $\tilde{q}$ can be manipulated. This is a standard monopsonistic effect.

B.4 Alternative tax rebates

In the baseline model redistribution motives at $t = 0$ are shut down by the choice of weight ϕ. Another way to shut it down is to directly compensate agents for changes in asset prices. This is enough to shut down redistribution at $t = 0$ since taxes do not change any other prices in this period. Below we show how analysis from Section 3 could be repeated in this setup to reach the same conclusions.

A tax system is a tuple $\mathcal{T} = \{\tau^N, \tau^T, \tilde{\tau}, T^e, T^w\}$. Let $\hat{q}^N$ and $\hat{q}^N$ be the debt prices corresponding to the unregulated equilibrium, the one with no intervention: $\tau^N = \tau^T = \tilde{\tau} = T^w = T^e = 0$. The constraint we impose on the lump-sum transfers is that, for any tax system $\mathcal{T} = \{\tau^N, \tau^T, \tilde{\tau}, T^e, T^w\}$,

$$T^w = p_0 b^N\left[q^N(\mathcal{T}) - \hat{q}^N\right] + b^T\left[q^T(\mathcal{T}) - \hat{q}^T\right] \tag{124}$$

$$T^e = p_0 b^N\left[\hat{q}^N - (1-\tau^N)q^N(\mathcal{T})\right] + b^T\left[\hat{q}^T - (1-\tau^T)q^T(\mathcal{T})\right] + \tilde{b}\left[\tilde{q} - (1-\tilde{\tau})\tilde{q}\right] \tag{125}$$

In words, the planner reimburses agents with the innovations to asset prices that taxes introduce. Since agents do not factor the effect of their decisions on rebates taxes still induce substitution effects. However, since price differences are compensated taxes don't induce income effects. The consumption-saving bundles chosen at $t = 0$ in the unregulated equilibrium are still available under any tax system $\mathcal{T}$. The budget is balanced:

$$T^w + T^e = p_0 b^N \tau^N q^N + b^T \tau^T q^T + \tilde{\tau}\tilde{q} \tag{126}$$

The planner's problem becomes

$$\max \phi \left((C_0^w)^{1-\zeta} + \beta_w \mathbb{E}[(C_1^w)^{1-\sigma}]^{\frac{1-\zeta}{1-\sigma}} \right) + (1-\phi) \left((C_0^e)^{1-\zeta_e} + \beta_e \mathbb{E}[(C_1^e)^{1-\sigma_e}]^{\frac{1-\zeta_e}{1-\sigma_e}} \right) \tag{127}$$

$$\text{s.t. } p_0^\alpha C_0^w = e_0^{w,T} + p_0 e_0^{N,w} - p_0 \hat{q}^N b^N - \hat{q}^T b^T \tag{128}$$

$$p_0^\alpha C_0^e = e_0^{e,T} + p_0 e_0^{e,N} + p_0 \hat{q}^N b^N + \hat{q}^T b^T + \tilde{q}\tilde{b} \tag{129}$$

$$p_1^\alpha C_1^w = e_1^{w,T} + p_1 e_1^{w,N} + w_1 l + b^T + p_1 b^N \tag{130}$$

$$p_1^\alpha C_1^e = e_1^{e,T} + p_1 e_1^{e,N} + f(z_1, l) - w_1 l - z_1 - b^T - p_1 b^N - \tilde{b} \tag{131}$$

$$q^T = \beta_w \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha} \frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}} \right] \mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}} \right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{132}$$

$$q^N = \beta_w \mathbb{E}\left[\frac{p_0^{1-\alpha}}{p_1^{1-\alpha}} \frac{(C_1^w)^{-\sigma}}{(C_0^w)^{-\sigma}} \right] \mathbb{E}\left[\frac{(C_1^w)^{1-\sigma}}{(C_0^w)^{1-\sigma}} \right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{133}$$

$$(1-\tau^T) q^T = \beta_e \mathbb{E}\left[\frac{p_0^\alpha}{p_1^\alpha} \frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}} \cdot (1 + \theta^{-1}\delta_1(f_z(z_1, l_1) - 1)) \right] \mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}} \right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{134}$$

$$(1-\tau^N) q^N = \beta_e \mathbb{E}\left[\frac{p_0^{1-\alpha}}{p_1^{1-\alpha}} \frac{(C_1^e)^{-\sigma_e}}{(C_0^e)^{-\sigma_e}} \cdot (1 + \theta^{-1}\delta_1(f_z(z_1, l_1) - 1)) \right] \mathbb{E}\left[\frac{(C_1^e)^{1-\sigma_e}}{(C_0^e)^{1-\sigma_e}} \right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{135}$$

$$(1-\tau^T) q^T = (1-\tilde{\tau})\tilde{q} \tag{136}$$

$$p_1 = \frac{\alpha}{1-\alpha} \frac{f(z_1, l) - z_1 + e_1^{w,T} + e_1^{e,T} - \tilde{b}}{e_1^{w,N} + e_1^{e,N}} \tag{137}$$

$$z_1 = \min\left\{ \bar{z}, \theta^{-1}(p_1(\bar{b} - b^N) - b^T - \tilde{b}) \right\} \tag{138}$$

$$w_1 = f_l(z_1, l) \tag{139}$$

The only difference with the baseline problem is that now the budget constraints in (128), (129), (130), and (131) include $\hat{q}^T$ and $\hat{q}^N$ instead of q^T and q^N. This difference is very important, as $(q^T, q^N, \tau^T, \tau^N, \tilde{\tau})$ now only appear in (132), (133), (134), (135), and (136). We can solve the problem without regard for $(q^T, q^N, \tau^T, \tau^N, \tilde{\tau})$ first, and then set them residually using these equations. The other block of the problem solution, the variables (p_1, z_1, w_1), can be treated exactly the same way as in the baseline.

The advantage of this approach is that we can characterize the marginal benefits of increasing debt for any $\phi \in [0, 1]$ without having to track the change in asset prices. The disadvantage is that marginal benefits will depend on the benchmark asset prices $(\hat{q}^T, \hat{q}^N)$.

The next proposition computes these benefits analogously to Proposition 1:

Proposition 3. The net marginal benefits from increasing debt in tradables are given by

$$\frac{\partial \mathcal{W}}{\partial b^T} = \underbrace{\mathbb{E}[\mathcal{U}_1^e \cdot (\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1)]}_{\text{Fisherian amplification}} + \underbrace{\mathbb{E}[(\mathcal{U}_1^w - \mathcal{U}_1^e) \cdot \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l_1)]}_{\text{endowment revaluation}}$$
$$+ \underbrace{[\mathcal{U}_0^w \cdot (q^T - \hat{q}^T) + \mathcal{U}_0^e \cdot (\hat{q}^T - (1-\tau^T) q^T)]}_{\text{portfolio distortion}} \tag{140}$$

The net marginal benefits from increasing debt in non-tradables are given by

$$\frac{\partial \mathcal{W}}{\partial b^N} = \mathbb{E}[\mathcal{U}_1^e \cdot p_1(\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1)] + \mathbb{E}[(\mathcal{U}_1^w - \mathcal{U}_1^e) \cdot p_1 \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l_1)] \\ + p_0[\mathcal{U}_0^w \cdot (q^N - \hat{q}^N) + \mathcal{U}_0^e \cdot (\hat{q}^N - (1-\tau^N)q^N)] \tag{141}$$

Here $m_1^w = b^N + e_1^{N,w} - c_1^{N,w}$, and marginal utilities are

$$\mathcal{U}_0^w = \phi(1-\zeta)\frac{(C_0^w)^{-\zeta}}{p_0^\alpha} \tag{142}$$

$$\mathcal{U}_1^w = \beta^w \phi(1-\zeta)\frac{(C_1^w)^{-\sigma}}{p_1^\alpha}\mathbb{E}\left[(C_1^w)^{1-\sigma}\right]^{\frac{\sigma-\zeta}{1-\sigma}} \tag{143}$$

$$\mathcal{U}_0^e = (1-\phi)(1-\zeta_e)\frac{(C_0^e)^{-\zeta_e}}{p_0^\alpha} \tag{144}$$

$$\mathcal{U}_1^e = \beta^e(1-\phi)(1-\zeta_e)\frac{(C_1^w)^{-\sigma_e}}{p_1^\alpha}\mathbb{E}\left[(C_1^w)^{1-\sigma_e}\right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} \tag{145}$$

The first terms in (140) and (141) are positive if the constraint binds with positive probability. If the weight ϕ is such that $\mathcal{U}_0^w = \mathcal{U}_0^e$, then (140) and (141) collapse to (38) and (40) in Proposition 1.

The main difference between (140) and its analog (38) in Proposition 1 is the last term. Instead of measuring the gap between the private and social value of transferring resources from $t = 0$ to $t = 1$, it now captures the cost of suppressing savings as measured by the change in the market interest rates. If $q^T > \hat{q}^T$, lower interest rates show that there is under-saving from the private perspective of the workers. If $\hat{q}^T > (1-\tau^T)q^T$, higher after-tax interest rates show that there is under-borrowing from the private perspective of the borrowers.

We now use the expressions for marginal costs of deleveraging to describe the constrained-efficient allocation under $\phi = 1$, with a full focus on the workers, and under $\phi = 0$, focusing on the entrepreneurs. These special case allows for a clear explanation of the economics behind the intervention. Define the appreciation of the domestic currency as $s_1 \equiv p_1/p_0$.

Corollary 2. Under $\phi = 1$, the constrained-efficient allocation satisfies

$$\hat{q}^T - q^T = \mathbb{E}\left[\Lambda^w \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l_1)\right] \tag{146}$$

$$\hat{q}^N - q^N = \mathbb{E}\left[\Lambda^w \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l_1) \cdot s_1\right] \tag{147}$$

Here Λ^w is the pricing kernel of the workers, $\Lambda^w = \mathcal{U}_1^w/\mathcal{U}_0^w$. Under $\phi = 0$, the constrained-efficient allocation satisfies

$$(1-\tau^T)q^T - \hat{q}^T = \mathbb{E}[\Lambda^e((\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1) - \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l_1))] \tag{148}$$

$$(1-\tau^N)q^N - \hat{q}^N = \mathbb{E}[\Lambda^e((\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1) - \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l_1)) \cdot s_1] \tag{149}$$

Here Λ^e is the pricing kernel of the entrepreneurs, $\Lambda^e = \mathcal{U}_1^e/\mathcal{U}_0^e$. If the weight ϕ is such that $\mathcal{U}_0^w = \mathcal{U}_0^e$, then the social optimum satisfies (46) and (47) in Corollary 1.

These expressions equate the marginal costs of distorting portfolio choice to the marginal benefits of clearing the balance sheets of excess debt. The marginal costs of portfolio distortion are captured by the difference between the unregulated interest rate and the interest rate the workers ask for at the new debt levels. Lower interest rates, for instance, mean that they under-save from their private perspective. The marginal benefit of intervention is captured by the balance sheet impact of debt on their non-financial income that the workers do not internalize. To see the intuition behind this, consider, as in the baseline model, the true payoff of a foreign currency claim at $t = 1$:

$$(\text{true payoff})_{t=1} = (\text{claim payout})_{t=1} + \underbrace{\mathcal{Z}_1 \mathcal{D}_1^w l_1 + \mathcal{Z}_1 \mathcal{D}_1^p m_1^w}_{\text{not internalized}} \tag{150}$$

Workers do not take into account the effect of their savings on the wage bill they will receive, as in Bocola and Lorenzoni (2020b). This term is negative when the constraint binds, so workers overestimate the payoff of having a claim maturing in these states. They also do not realize that the input use affects the exchange rate and revalues their net trading position in non-tradables, receipts less expenditures.

If the last terms in (150) are negative and the workers overestimate the payoff of their assets, the planner faces them with lower interest rates and forces them to internalize the balance sheet effects. The difference between the interest rates is exactly the expected discounted marginal effect of debt, as in Korinek (2018). This logic is the same for debt denominated in traded and non-traded goods, although the payoff of the latter is correlated with the exchange rate and loses value in times of depreciation.

The logic is exactly the same in the case $\phi = 0$. The planner changes the interest rates that the entrepreneurs face in accordance with the strength of the effects they do not internalize. If the expressions on the right-hand sides of (148) and (148) are negative, the planner makes sure that the after-tax asset prices $(1 - \tau^T)q^T$ and $(1 - \tau^N)q^N$ are lower than those in the unregulated equilibrium. This means that borrowing is more expensive and the entrepreneurs are forced to incur less liabilities.

Marginal de-dollarization. We now study the benefits of de-dollarization, again setting $\phi = 1$ or $\phi = 0$ for tractability. As in the baseline model, we consider the following perturbation: we increase the holdings of claims to non-traded goods b^N and decrease the holdings of claims to traded goods b^T by the same amount scaled by $\mathbb{E}[p_1]$. This increases the payouts in proportion to p_1 in each state but takes away a non-contingent portion (because foreign currency payouts are constant across states). Moreover, this non-contingent decrease in payouts due to lower b^T is equal to the expected increase due to raising b^N.

Formally, the marginal change in welfare we compute is

$$\Delta^i = \frac{1}{p_0 \mathcal{U}_0^i} \left(\frac{d\mathcal{W}}{db^N} - \mathbb{E}[p_1] \frac{d\mathcal{W}}{db^T} \right), \ i \in \{w, e\} \tag{151}$$

The following proposition is the analog of Proposition 2:

Proposition 4. Suppose $\phi = 1$. Then,

$$\Delta^w = \underbrace{\mathbb{C}\left[\Lambda^w \mathcal{Z}_1 (\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l_1), s_1\right]}_{\text{removing contagion}} - \underbrace{\left[\Delta_{UIP}^w - \hat{\Delta}_{UIP}\right]}_{\text{insurance loss}} + \underbrace{\mathbb{E}\left[s_1 - \hat{s}_1\right] \hat{q}^T}_{\text{revaluation}} \tag{152}$$

Here $\hat{s}_1 = \hat{p}_1/p_0$ stands for appreciation of the domestic currency in the unregulated equilibrium, $\Delta^w_{UIP} = q^T \mathbb{E}[s_1] - q^N$ and $\hat{\Delta}_{UIP} = \hat{q}^T \mathbb{E}[\hat{s}_1] - \hat{q}^N$. Under $\phi = 0$,

$$\Delta^e = \mathbb{C}[\Lambda^e((\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1, l) - 1) - \mathcal{Z}_1(\mathcal{D}^p_1 m^w_1 + \mathcal{D}^w_1 l_1)), s_1] + [\Delta^e_{UIP} - \hat{\Delta}_{UIP}] - \mathbb{E}[s_1 - \hat{s}_1]\hat{q}^T \tag{153}$$

Here $\Delta^e_{UIP} = (1 - \tau^T)q^T \mathbb{E}[s_1] - (1 - \tau^N)q^N$. If the weight ϕ is such that $\mathcal{U}^w_0 = \mathcal{U}^e_0$, then $\Delta^e = \Delta^w$ and they are both given by (43) in Proposition 2.

The main difference between this result and Proposition 2 is the last term in (152) and (153). This is an artifact of the tax system that effectively transfers resources between $t = 0$ and $t = 1$ at benchmark asset prices $\hat{q}^T$ and $\hat{q}^N$. They do not change to reflect the changes in the distribution of p_1, which creates relative mispricing.

As a result, savers benefit from the strengthening of domestic currency if that is what macroprudential policy leads to.

All other takeaways from Proposition 4 are the same as those from Proposition 2. Benefits to dedollarization stem from making the uninternalized effects of debt less correlated with the exchange rate, which increase welfare if marginal utility is high in times of depreciation. The insurance losses (in the case of workers) and benefits (in the case of entrepreneurs) can be measured by the change in the UIP violation relative to the unregulated equilibrium. Insurance terms in both (152) and (153) are zero when taxes are zero, so this effect is of second order.

B.5 Details on example from Section 3

Recall that the setup for the example assumes that $\theta = 1$ and that $f(z, l)$ is separable over z and l. We also take the following limits: $l \to 0$, $\alpha \to 0$, $e^{N,w}_1 + e^{N,e}_1 \to 0$, $\alpha/(e^{N,w}_1 + e^{N,e}_1) \to 1$. This leads to the following expressions for p_1 and z_1:

$$p_1 = f(z_1, 0) - z_1 + y^T_1 - \tilde{b} \tag{154}$$

$$z_1 = (f(z_1, 0) - z_1 + y^T_1 - \tilde{b})(\bar{b} - b^N) - b^T - \tilde{b} \tag{155}$$

The marginal effect $\mathcal{Z}_1$ and $\mathcal{D}^p_1$ are given by

$$\mathcal{D}^1_p = f_z(z_1, 0) - 1 = \gamma \tag{156}$$

$$\mathcal{Z}_1 = \mathcal{Z}_1(f_z(z_1, 0) - 1)(\bar{b} - b^N) - 1 = -\frac{1}{1 - (f_z(z_1, 0) - 1)(\bar{b} - b^N)} = -\frac{1}{1 - \gamma(\bar{b} - b^N)} \tag{157}$$

The total derivatives of z_1 and p_1 with respect to y^T_1 are

$$\frac{dz_1}{dy_1} = \frac{dz_1}{dy_1}(f_z(z_1, 0) - 1)(\bar{b} - b^N) + (\bar{b} - b^N) = \frac{\bar{b} - b^N}{1 - \gamma(\bar{b} - b^N)} \tag{158}$$

$$\frac{dp_1}{dy_1} = \frac{dz_1}{dy_1}(f_z(z_1, 0) - 1) + 1 = \frac{1}{1 - \gamma(\bar{b} - b^N)} \tag{159}$$

For both of these derivatives to be positive, it is sufficient that $b^N \in \left(\bar{b} - 1/\gamma, \bar{b}\right)$ for all realizations of γ. This can be ensured by setting suitable endowments.

Numerical example. We now show a specific parameterization.

Table 2: Parameters for a numerical example

	Description	Value
σ	risk-aversion of the workers	1
ζ	inverse IES of the workers	1
β_w	discount factor of the workers	1
σ_e	risk-aversion of the entrepreneurs	0
ζ_e	inverse IES of the entrepreneurs	0
β_e	discount factor of the entrepreneurs	1
$f(z,l)$	production function	$2\sqrt{z}+2\sqrt{l}$
$e_1^{T,w}$	tradable endowment of the workers at $t=1$	0
$e_0^{T,w}$	tradable endowment of the workers at $t=0$	4
$e_1^{T,e}(\bar{\epsilon})$	tradable endowment of the entrepreneurs at $t=1$ in high state	1
$e_1^{T,e}(\bar{\epsilon})$	tradable endowment of the entrepreneurs at $t=1$ in low state	0.25
$\pi(\bar{\epsilon})$	probability of the high state	0.5
$\tilde{b}$	supply of foreign investment	0
$\bar{b}$	borrowing limit	1.25

Workers have log utility, entrepreneurs have linear utility, and production function is concave. It can be verified that $(b^N, b^T) = (1, 0)$ is an equilibrium portfolio. Start from the distribution of the exchange rate and input use that it generates.

$$p_1(\epsilon) = 2\sqrt{z_1(\epsilon)} - z_1(\epsilon) + e_1^{T,e}(\epsilon) \tag{160}$$

The unconstrained optimal level of input use is $\bar{z} = 1$. In the high state, the constraint is slack, so $p_1(\bar{\epsilon}) = 2$ and $z_1(\bar{\epsilon}) = 1$. In the low state, the constraint binds, and

$$z_1(\underline{\epsilon}) = (2\sqrt{z_1(\underline{\epsilon})} - z_1(\underline{\epsilon}) + 0.25) \cdot (1.25 - 1) - 0 \tag{161}$$

This quadratic equation has a unique positive solution $z_1(\underline{\epsilon}) = 0.25$, leading to $p_1(\underline{\epsilon}) = 1$. The asset prices are equal to $q^T = \mathbb{E}[f_z(z_1, 0)]$ and $p_0 q^N = \mathbb{E}[f_z(z_1, 0) p_1]$. This leads to $q^T = 1.5$ and $p_0 q^N = 2$, and $C_0^w = 2$ follows from $e_0^{T,w} = 4$ and $(b^N, b^T) = (1, 0)$.

Lastly, we need to verify the workers' Euler equations:

$$q^T = 0.5 \cdot \frac{C_0^w}{C_1^w(\bar{\epsilon})} + 0.5 \cdot \frac{C_0^w}{C_1^w(\underline{\epsilon})} \tag{162}$$

$$p_0 q^N = 0.5 \cdot p_1(\bar{\epsilon}) \frac{C_0^w}{C_1^w(\bar{\epsilon})} + 0.5 \cdot p_1(\underline{\epsilon}) \frac{C_0^w}{C_1^w(\underline{\epsilon})} \tag{163}$$

Since $C_1^w(\epsilon) = p_1(\epsilon) \cdot 1$ for both states, these equations hold. In this equilibrium, it also holds that $b^N \in (\bar{b} - 1/\gamma(\epsilon), \bar{b})$ for both ϵ, so the monotonicity condition is satisfied.

B.6 Proofs

Proof. (of Proposition 3) For a fixed pair (b^T, b^N), let $\mathcal{W}$ be the value of the objective in (127) maximized over $(C_0^w, C_0^e, q^T, q^N, \tau^T, \tau^N, \tilde{\tau})$, and $(C_1^w, C_1^e, w_1, p_1, z_1)$ for any realization of the shock ϵ. Let λ_0^w, λ_0^e, λ_1^w, and λ_1^e be the multipliers on the constraints (128), (129), (130), and (131) respectively. Taking the derivative with respect to C_0^w, C_0^e, C_1^w, and C_1^e,

$$\phi(1-\zeta)(C_0^w)^{-\zeta} = p_0^\alpha \lambda_0^w \tag{164}$$

$$(1-\phi)(1-\zeta_e)(C_0^e)^{-\zeta_e} = p_0^\alpha \lambda_0^e \tag{165}$$

$$\pi_1 \cdot \phi(1-\zeta)\beta^w (C_1^w)^{-\sigma}\mathbb{E}\left[(C_1^w)^{1-\sigma}\right]^{\frac{\sigma-\zeta}{1-\sigma}} = p_1^\alpha \lambda_1^w \tag{166}$$

$$\pi_1 \cdot (1-\phi)(1-\zeta_e)\beta^e (C_1^e)^{-\sigma_e}\mathbb{E}\left[(C_1^e)^{1-\sigma_e}\right]^{\frac{\sigma_e-\zeta_e}{1-\sigma_e}} = p_1^\alpha \lambda_1^e \tag{167}$$

Here π_1 is the probability of the specific realization of ϵ. Taking the derivative of the objective with respect to b^T and b^N that are treated as parameters,

$$\begin{aligned}\frac{\partial \mathcal{W}}{\partial b^T} &= \hat{q}^T(\lambda_0^e - \lambda_0^w) + \sum \left[\frac{\partial P}{\partial z_1}\frac{\partial Z}{\partial b^T}(\lambda_1^w(e_1^{N,w} + b^N - \alpha p_1^{\alpha-1}C_1^w) + \lambda_1^e(e_1^{N,e} - b^N - \alpha p_1^{\alpha-1}C_1^e))\right] \\ &+ \sum\left[\frac{\partial W}{\partial z_1}\frac{\partial Z}{\partial b^T} l(\lambda_1^w - \lambda_1^e)\right] + \sum\left[\frac{\partial Z}{\partial b^T}\lambda_1^e(f_z(z_1, l_1) - 1)\right] + \sum[\lambda_1^w - \lambda_1^e] \qquad (168)\\ \frac{\partial \mathcal{W}}{\partial b^N} &= \hat{q}^N p_0(\lambda_0^e - \lambda_0^w) + \sum \left[\frac{\partial P}{\partial z_1}\frac{\partial Z}{\partial b^N}(\lambda_1^w(e_1^{N,w} + b^N - \alpha p_1^{\alpha-1}C_1^w) + \lambda_1^e(e_1^{N,e} - b^N - \alpha p_1^{\alpha-1}C_1^e))\right] \\ &+ \sum\left[\frac{\partial W}{\partial z_1}\frac{\partial Z}{\partial b^N} l(\lambda_1^w - \lambda_1^e)\right] + \sum\left[\frac{\partial Z}{\partial b^N}\lambda_1^e(f_z(z_1, l_1) - 1)\right] + \sum[(\lambda_1^w - \lambda_1^e)p_1] \qquad (169)\end{aligned}$$

Here the functions $Z(b^T, b^N, \epsilon)$, $P(z_1, b^T, b^N, \epsilon)$, and $W(z_1)$ result from solving the system of (137), (139), and (138). Using the notation $\mathcal{Z}_1$, $\mathcal{D}_1^p$, and $\mathcal{D}_1^W$ for their derivatives, plugging (164), (165), (166), and (167), and using the definitions of $\mathcal{U}_0^w$, $\mathcal{U}_0^e$, $\mathcal{U}_1^w$, and $\mathcal{U}_1^e$,

$$\begin{aligned}\frac{\partial \mathcal{W}}{\partial b^T} &= \hat{q}^T(\mathcal{U}_0^e - \mathcal{U}_0^w) + \mathbb{E}\left[\mathcal{Z}_1\mathcal{D}_1^p(\mathcal{U}_1^w(e_1^{N,w} + b^N - \alpha p_1^{\alpha-1}C_1^w) + \mathcal{U}_1^e(e_1^{N,e} - b^N - \alpha p_1^{\alpha-1}C_1^e))\right] \\ &+ \mathbb{E}\left[\mathcal{Z}_1\mathcal{D}_1^w l(\mathcal{U}_1^w - \mathcal{U}_1^e)\right] + \mathbb{E}\left[\mathcal{U}_1^e\mathcal{Z}_1(f_z(z_1, l_1) - 1)\right] + \mathbb{E}\left[\mathcal{U}_1^w - \mathcal{U}_1^e\right] \qquad (170)\\ \frac{\partial \mathcal{W}}{\partial b^N} &= \hat{q}^N p_0(\mathcal{U}_0^e - \mathcal{U}_0^w) + \mathbb{E}\left[p_1 \cdot \mathcal{Z}_1\mathcal{D}_1^p(\mathcal{U}_1^w(e_1^{N,w} + b^N - \alpha p_1^{\alpha-1}C_1^w) + \mathcal{U}_1^e(e_1^{N,e} - b^N - \alpha p_1^{\alpha-1}C_1^e))\right] \\ &+ \mathbb{E}\left[p_1 \cdot \mathcal{Z}_1\mathcal{D}_1^w l(\mathcal{U}_1^w - \mathcal{U}_1^e)\right] + \mathbb{E}\left[p_1 \cdot \mathcal{Z}_1\mathcal{U}_1^e(f_z(z_1, l_1) - 1)\right] + \mathbb{E}[p_1 \cdot (\mathcal{U}_1^w - \mathcal{U}_1^e)] \qquad (171)\end{aligned}$$

Using the fact that $\alpha p_1^{\alpha-1}C_1^e = c_1^e$, $\alpha p_1^{\alpha-1}C_1^w = c_1^w$, exploiting the market-clearing condition $c_1^w + c_1^e = e_1^{N,w} + e_1^{T,w}$, and denoting $m_1^w = e_1^{N,w} + b^N - c_1^w$,

$$\begin{aligned}\frac{\partial \mathcal{W}}{\partial b^T} &= \hat{q}^T(\mathcal{U}_0^e - \mathcal{U}_0^w) + \mathbb{E}\left[\mathcal{Z}_1\mathcal{D}_1^p(\mathcal{U}_1^w - \mathcal{U}_1^e)m_1^w\right] \\ &+ \mathbb{E}\left[\mathcal{Z}_1\mathcal{D}_1^w l(\mathcal{U}_1^w - \mathcal{U}_1^e)\right] + \mathbb{E}\left[\mathcal{U}_1^e\mathcal{Z}_1(f_z(z_1, l_1) - 1)\right] + \mathbb{E}\left[\mathcal{U}_1^w - \mathcal{U}_1^e\right] \qquad (172)\\ \frac{\partial \mathcal{W}}{\partial b^N} &= \hat{q}^N p_0(\mathcal{U}_0^e - \mathcal{U}_0^w) + \mathbb{E}\left[p_1 \cdot \mathcal{Z}_1\mathcal{D}_1^p(\mathcal{U}_1^w - \mathcal{U}_1^e)m_1^w\right] \\ &+ \mathbb{E}\left[p_1 \cdot \mathcal{Z}_1\mathcal{D}_1^w l(\mathcal{U}_1^w - \mathcal{U}_1^e)\right] + \mathbb{E}\left[p_1 \cdot \mathcal{Z}_1\mathcal{U}_1^e(f_z(z_1, l_1) - 1)\right] + \mathbb{E}[p_1 \cdot (\mathcal{U}_1^w - \mathcal{U}_1^e)] \qquad (173)\end{aligned}$$

Using (132), (133), (134), and (135), we can substitute

$$\mathbb{E}\left[\mathcal{U}_1^w\right] = q^T \mathcal{U}_0^w \tag{174}$$

$$\mathbb{E}\left[\mathcal{U}_1^e(1+\theta^{-1}(f_z(z_1,l_1)-1))\right] = (1-\tau^T)q^T\mathcal{U}_0^e \tag{175}$$

$$\mathbb{E}\left[p_1\mathcal{U}_1^w\right] = q^N p_0 \mathcal{U}_0^w \tag{176}$$

$$\mathbb{E}\left[p_1\mathcal{U}_1^e(1+\theta^{-1}(f_z(z_1,l_1)-1))\right] = (1-\tau^N)p_0 q^N \mathcal{U}_0^e \tag{177}$$

Plugging this,

$$\begin{aligned}\frac{\partial \mathcal{W}}{\partial b^T} &= \mathcal{U}_0^e(\hat{q}^T-(1-\tau^T)q^T)+\mathcal{U}_0^w(q^T-\hat{q}^T)+\mathbb{E}\left[(\mathcal{U}_1^w-\mathcal{U}_1^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)\right] \\ &+\mathbb{E}\left[\mathcal{U}_1^e(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l_1)-1)\right] \end{aligned}\tag{178}$$

$$\begin{aligned}\frac{\partial \mathcal{W}}{\partial b^N} &= p_0\mathcal{U}_0^e(\hat{q}^N-(1-\tau^N)q^N)+p_0\mathcal{U}_0^w(q^N-\hat{q}^N)+\mathbb{E}\left[p_1\cdot(\mathcal{U}_1^w-\mathcal{U}_1^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)\right] \\ &+\mathbb{E}\left[p_1\cdot\mathcal{U}_1^e(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l_1)-1)\right] \end{aligned}\tag{179}$$

Finally, to see that Proposition 1 is nested, assume the weights are chosen such that $\mathcal{U}_0^w=\mathcal{U}_0^e$. Then, there is a number $\mathcal{U}_0=\mathcal{U}_0^w=\mathcal{U}_0^e$ such that we can write $\Lambda^w=\mathcal{U}_1^w/\mathcal{U}_0$ and $\Lambda^e=\mathcal{U}_1^e/\mathcal{U}_0$. Using this,

$$\begin{aligned}\frac{1}{\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^T} &= \hat{q}^T-(1-\tau^T)q^T+q^T-\hat{q}^T+\mathbb{E}\left[(\Lambda^w-\Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)\right] \\ &+\mathbb{E}\left[\Lambda^e(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l_1)-1)\right] \end{aligned}\tag{180}$$

$$\begin{aligned}\frac{1}{p_0\mathcal{U}_0}\frac{\partial \mathcal{W}}{\partial b^N} &= \hat{q}^N-(1-\tau^N)q^N+q^N-\hat{q}^N+\mathbb{E}\left[\frac{p_1}{p_0}\cdot(\Lambda^w-\Lambda^e)\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)\right] \\ &+\mathbb{E}\left[\frac{p_1}{p_0}\cdot\Lambda^e(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l_1)-1)\right] \end{aligned}\tag{181}$$

Cancelling out $\hat{q}^T$ and $\hat{q}^N$, this recovers (38) and (40) in Proposition 1. □

Proof. (of Corollary 2) First, suppose $\phi=1$. This means $\mathcal{U}_0^e=\mathcal{U}_1^e=0$. Plugging this into the expressions in Proposition 3,

$$\hat{q}^T-q^T=\mathbb{E}[\Lambda^w\cdot\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)] \tag{182}$$

$$p_0(\hat{q}^N-q^N)=\mathbb{E}[p_1\Lambda^w\cdot\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)] \tag{183}$$

Here $\Lambda^w=\mathcal{U}_1^w/\mathcal{U}_0^w$. With $p_1/p_0=s_1$, this leads to the first two expressions in Corollary 2. Now supposing $\phi=0$ and plugging $\mathcal{U}_0^w=\mathcal{U}_1^w=0$ instead,

$$(1-\tau^T)q^T-\hat{q}^T=\mathbb{E}[\Lambda^e\cdot(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l)-1)]-\mathbb{E}[\Lambda^e\cdot\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)] \tag{184}$$

$$p_0((1-\tau^N)q^N-\hat{q}^N)=\mathbb{E}[p_1\Lambda^e\cdot(\mathcal{Z}_1+\theta^{-1}\delta_1)(f_z(z_1,l)-1)]-\mathbb{E}[p_1\Lambda^e\cdot\mathcal{Z}_1(\mathcal{D}_1^p m_1^w+\mathcal{D}_1^w l)] \tag{185}$$

Here $\Lambda^e=\mathcal{U}_1^e/\mathcal{U}_0^e$. With $p_1/p_0=s_1$, this leads to the last two expressions in Corollary 2.

Finally, recovering Corollary 1 requires using the fact that the suitable weight ϕ collapses the expressions in Proposition 3 to those in Proposition 1. Corollary 1 follows immediately. □

Proof. (of Proposition 4) With $\phi = 1$, $\mathcal{U}_0^e = \mathcal{U}_1^e = 0$. Plugging this into Proposition 3,

$$\begin{aligned}
\frac{1}{p_0\mathcal{U}_0^w}\left(\frac{\partial\mathcal{W}}{\partial b^N} - \mathbb{E}[p_1]\frac{\partial\mathcal{W}}{\partial b^T}\right) &= \mathbb{E}[\Lambda^w\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)\cdot s_1] - \mathbb{E}[\Lambda^w\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)]\cdot\mathbb{E}[s_1] \\
&+ (q^N - \mathbb{E}[s_1]q^T) - (\hat{q}^N - \mathbb{E}[s_1]\hat{q}^T) \\
&= \mathbb{C}[\Lambda^w\mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l), s_1] - (\mathbb{E}[s_1]q^T - q^N) + (\mathbb{E}[\hat{s}_1]\hat{q}^T - \hat{q}^N) \\
&+ \hat{q}^T(\mathbb{E}[s_1] - \mathbb{E}[\hat{s}_1])
\end{aligned} \tag{186}$$

Here $\Lambda^w = \mathcal{U}_1^w/\mathcal{U}_0^w$. Denoting $\Delta_{UIP}^w = \mathbb{E}[s_1]q^T - q^N$ and $\hat{\Delta}_{UIP} = \mathbb{E}[\hat{s}_1]\hat{q}^T - \hat{q}^N$ leads to the first expression in Proposition 4.

Under $\phi = 0$, $\mathcal{U}_0^w = \mathcal{U}_1^w = 0$. Plugging this into the expressions from Proposition 3,

$$\begin{aligned}
\frac{1}{p_0\mathcal{U}_0^e}\left(\frac{\partial\mathcal{W}}{\partial b^N} - \mathbb{E}[p_1]\frac{\partial\mathcal{W}}{\partial b^T}\right) &= \mathbb{E}[\Lambda^e((\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1,l) - 1) - \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l))\cdot s_1] \\
&- \mathbb{E}[\Lambda^e((\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1,l) - 1) - \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l))]\cdot\mathbb{E}[s_1] \\
&- ((1-\tau^N)q^N - \mathbb{E}[s_1](1-\tau^T)q^T) + (\hat{q}^N - \mathbb{E}[s_1]\hat{q}^T) \\
&= \mathbb{C}[\Lambda^e((\mathcal{Z}_1 + \theta^{-1}\delta_1)(f_z(z_1,l) - 1) - \mathcal{Z}_1(\mathcal{D}_1^p m_1^w + \mathcal{D}_1^w l)), s_1] \\
&+ (\mathbb{E}[s_1](1-\tau^T)q^T - (1-\tau^N)q^N) - (\mathbb{E}[\hat{s}_1]\hat{q}^T - \hat{q}^N) \\
&- \hat{q}^T(\mathbb{E}[s_1] - \mathbb{E}[\hat{s}_1])
\end{aligned} \tag{187}$$

Here $\Lambda^e = \mathcal{U}_1^e/\mathcal{U}_0^e$. Denoting $\Delta_{UIP}^e = (1-\tau^T)q^T\mathbb{E}[s_1] - (1-\tau^N)q^N$ and $\hat{\Delta}_{UIP} = \mathbb{E}[\hat{s}_1]\hat{q}^T - \hat{q}^N$ leads to the second expression in Proposition 4.

Finally, recovering Proposition 2 requires using the fact that the suitable weight ϕ collapses the expressions in Proposition 3 to those in Proposition 1. Proposition 2 then follows through the step in its proof. □

C Details for numerical illustration

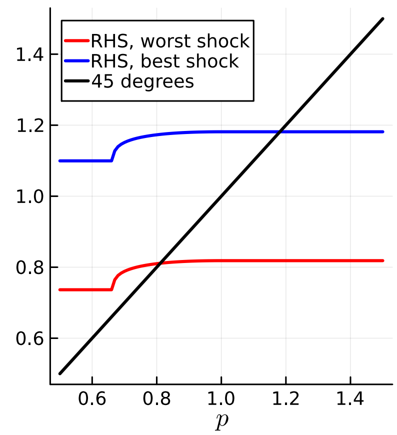
One concern with the quantification is that there could be multiple equilibria at $t = 1$: a low value of p results in low z that confirms that p, but if p had been higher, z would have increased enough to justify that value of p. Mathematically, this would mean that $z_1 = p(z_1, \epsilon)(\bar{b} - b^N) - b^T - \tilde{b}$ has two solutions. Alternatively, if z_1 is treated as a function $\hat{z}(p_1, b^T, b^N, \tilde{b})$,

$$p_1 = \frac{\alpha}{1-\alpha}\frac{f(\hat{z}(p_1, b^T, b^N, \tilde{b}), l) - \hat{z}(p_1, b^T, b^N, \tilde{b}) + e_1^{T,w} + e_1^{T,e} - \tilde{b}}{e_1^{N,w} + e_1^{N,e}} \tag{188}$$

has multiple solutions p_1.

Figure 4 shows this is not the case in our calibration. Each colored line shows the right hand side of (188) as a function of p_1 given a realization of $\epsilon = (e_1^{N,w}, e_1^{N,e})$. A product market equilibrium is where this line crosses the 45-degree line. The colored lines are increasing as long as the borrowing constraint of firms is binding. The red line shows the right hand side of (188) for a lowe realization of the tradable endowment. Parameters are picked in a way that makes the constraint bind whenever $p_1 < 1$. The right-hand side (RHS) starts bending down to the left of that, since p_1 determines $\hat{z}$, and the line inherits concavity of $f(z, l) - z$.

Figure 4: Uniqueness of the equilibrium



We use the same parameters in Section 4. Table 3 lists them.

Table 3: Parameters for numerical illustration from Section 4

	Description	Value
$f(z,l)$	production function	$\left(\eta z^{1-1/\rho} + (1-\eta) l^{1-1/\rho}\right)^{\frac{\rho}{\rho-1}}$
η	weight on z in production	0.5
ρ	elasticity of substitution between z and l	1.25
σ	risk-aversion of the workers	2.825
ζ	inverse IES of the workers	0.6
β_w	discount factor of the workers	1
σ_e	risk-aversion of the entrepreneurs	0
ζ_e	inverse IES of the entrepreneurs	0
β_e	discount factor of the entrepreneurs	0.824
α	consumption weight on non-tradables	0.5
$e_1^{T,w}$	workers' traded endowment of at $t=1$	0
$e_0^{T,w}$	workers' traded endowment of at $t=0$	4.582
$e_1^{N,w}$	workers' non-traded endowment at $t=1$	4
$e_0^{N,w}$	workers' non-traded endowment at $t=0$	0
$[e_1^{T,e}(\underline{\epsilon}), e_1^{T,e}(\overline{\epsilon})]$	entrepreneurs' traded endowments at $t=1$	[2.278, 3.367]
$e_1^{N,e}$	entrepreneurs' non-traded endowment at $t=1$	0
p_0	exchange rate at $t=0$	0.959
$\tilde{b}$	supply of foreign investment	0.1
$\bar{b}$	borrowing limit	1.301

The distribution of entrepreneurs' endowments at $t=1$ is piecewise uniform. It is a rescaling transformation of the distribution defined on $[0,1]$ with density 1.5 on $[0,0.5]$ and 0.5 on $(0.5,1]$, meaning that the left half of the support has a mass three times larger than the right half.

The choice of parameters is motivated by the following targets:

- $r^T = 1/(1+q^T) = 0.05$, a 5% interest rate on dollar debt
- $(b^T, b^N) = (0.3, 0.7)$, a 30% dollarization rate of savings with a normalization $b^T + b^N = 1$
- $r^N - r^T - \mathbb{E}[p_1/p_0 - 1] = 0.03$, a 3% UIP deviation
- $p_1 = 1$ as the minimal price level under which the constraint is slack
- $p_1 = 1$ as the equilibrium exchange rate when $e_1^{T,e}$ is in the middle of its support
- the constraint binding 75% of the time

The first three targets add realism in the aspects we attach importance to. The last three we choose for convenience.

We pick the lower bound of the support of $e_1^{T,e}(\epsilon)$ so that if the support was 33% wider, at the lowest point there would be exactly two solutions for (188). This is a safety measure ensuring that the economy does not exhibit multiple equilibria even for some debt levels above $(b^N, b^T, \tilde{b}) = (0.7, 0.3, 0.1)$ (the red line in Figure 4 does not move down too much) and our search algorithm always has a unique solution for the exchange rate.

D Borrowing constraint micro-fundation

Seizable endowments. In the main text, we assumed that borrowers are subject to an intra-day borrowing constraint that limits how much of the tradable input they can buy:

$$\theta z_t + \tilde{b}_t + b_t^T + p_t b_t^N \leq p_t \bar{b}$$

This can be derived from the following micro-foundations. Assume that after production is done but before debt repayment and consumption take place, borrowers have the option to default on any part of their debt. In that case, the only cost is that the 'bank' seizes a fixed amount of entrepreneur's non-tradable endowment, $\bar{y}^{N,e}$. It follows that if they default, entrepreneurs would default on the total amount of their debt and that they only consider the impact of defaulting on current income. For them not to default, it has to be that

$$\theta z_t + \tilde{b}_t + b_t^T + p_t b_t^N \leq p_t \bar{y}^N$$

which maps directly into the borrowing constraint we have assumed. What we are trying to capture by assuming that the bank seizes $\bar{y}^N$ is that the bank takes part of the capital goods or real estate in the power of entrepreneurs for a period of time and appropriates the rents associated with it. Because we do not have capital in the model, we focus on the non-tradable part of endowments. This microfoundation requires assuming $\bar{y}^N < y_t^{N,e}$ for all t.

Local capital. Another way to microfound the borrowing constraint is to assume that entrepreneurs operate locally traded capital (land or immovable structures) that the financial intermediaries can seize and turn into non-traded goods. The entrepreneurs' production function is $f(z_t, l_t) = F(z_t, l_t; k_t)$, and the supply of capital is fixed at $k_t = \bar{b}$. If seized, this capital is sold as the non-traded good at price p_t.

Suppose the financial intermediaries guarantee workers' savings. Then, if entrepreneurs default on debt, the losses of intermediaries are $\theta z_t + \tilde{b}_t + b_t^T + p_t b_t^N - p_t \bar{b}$. If the intermediaries cannot accept any possibility of losses, they have to ensure

$$\theta z_t + \tilde{b}_t + b_t^T + p_t b_t^N \leq p_t \bar{b}$$

This formulation puts no restrictions on non-traded endowments of entrepreneurs.

E Decomposition of welfare changes

We conduct the following procedure to decompose welfare changes into efficiency gains, redistribution, and risk-sharing terms. Observe that the worker's value is determined by the following variables: vectors $\boldsymbol{p}$ and $\boldsymbol{w}$ of exchange rate and wage realizations corresponding to realizations of the shock to tradable endowments, taxes $\boldsymbol{\tau} = (\tau^T, \tau^N)$, asset prices $\boldsymbol{q} = (q^N, q^T)$, and portfolio $\boldsymbol{b} = (b^N, b^T)$. The entrepreneur's value is determined by the same vectors and the vector of traded input realizations $\boldsymbol{z}$. Notice that the worker's value only depends on $\boldsymbol{z}$ indirectly through wages and exchange rates. With a slight abuse of notation, let $\mathcal{V}^w(\boldsymbol{p}, \boldsymbol{w}, \boldsymbol{b}, \boldsymbol{q}, \boldsymbol{\tau})$ be the value of the worker given these vectors. Similarly, let $\mathcal{V}^e(\boldsymbol{z}, \boldsymbol{p}, \boldsymbol{w}, \boldsymbol{b}, \boldsymbol{q}, \boldsymbol{\tau})$ be the value of the entrepreneur.

The welfare changes for these agents can be computed as

$$\Delta^w = \mathcal{V}^w(\boldsymbol{p}^{opt}, \boldsymbol{w}^{opt}, \boldsymbol{b}^{opt}, \boldsymbol{q}^{opt}, \boldsymbol{\tau}^{opt}) - \mathcal{V}^w(\boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{189}$$

$$\Delta^e = \mathcal{V}^e(\boldsymbol{z}^{opt}, \boldsymbol{p}^{opt}, \boldsymbol{w}^{opt}, \boldsymbol{b}^{opt}, \boldsymbol{q}^{opt}, \boldsymbol{\tau}^{opt}) - \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{190}$$

Here $\boldsymbol{p}^{eqm}$, $\boldsymbol{w}^{eqm}$, and $\boldsymbol{z}^{eqm}$ are vectors of the exchange rate, wages, and input use in the unregulated equilibrium. The unregulated portfolio and asset prices are $\boldsymbol{b}^{eqm}$ and $\boldsymbol{q}^{eqm}$, and taxes are zero. Similarly, $\boldsymbol{p}^{opt}$, $\boldsymbol{w}^{opt}$, and $\boldsymbol{z}^{opt}$ are vectors of the exchange rate, wages, and input use in the social optimum under taxes $\boldsymbol{\tau}^{opt}$ with portfolio $\boldsymbol{b}^{opt}$ and prices $\boldsymbol{q}^{opt}$.

We compute counterfactual, off-equilibrium changes in welfare that would be caused by each vector changing from the unregulated equilibrium to the optimum separately. We define efficiency gains as

$$\Delta^{\text{efficiency},e} = \mathcal{V}^e(\boldsymbol{z}^{opt}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) - \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{191}$$

Here we hold all distributions except that for input use $\boldsymbol{z}$ at the unregulated equilibrium. This term represents efficiency gains because it reflects changes in resources available to the economy as a whole when the optimal policy is implemented. Similarly, welfare changes associated with redistribution result from changes in $\boldsymbol{p}$ and $\boldsymbol{w}$, since these are prices of goods exchanged internally within the country:

$$\Delta^{\text{wage},w} = \mathcal{V}^w(\boldsymbol{p}^{eqm}, \boldsymbol{w}^{opt}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) - \mathcal{V}^w(\boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{192}$$

$$\Delta^{\text{wage},e} = \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{opt}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) - \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{193}$$

$$\Delta^{\text{exchange rate},w} = \mathcal{V}^w(\boldsymbol{p}^{opt}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) - \mathcal{V}^w(\boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{194}$$

$$\Delta^{\text{exchange rate},e} = \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{opt}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) - \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{195}$$

Changes coming from portfolio distortions illustrate changes in risk-sharing:

$$\Delta^{\text{risk-sharing},w} = \mathcal{V}^w(\boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{opt}, \boldsymbol{q}^{opt}, \boldsymbol{\tau}^{opt}) - \mathcal{V}^w(\boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{196}$$

$$\Delta^{\text{risk-sharing},e} = \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{opt}, \boldsymbol{q}^{opt}, \boldsymbol{\tau}^{opt}) - \mathcal{V}^e(\boldsymbol{z}^{eqm}, \boldsymbol{p}^{eqm}, \boldsymbol{w}^{eqm}, \boldsymbol{b}^{eqm}, \boldsymbol{q}^{eqm}, 0) \tag{197}$$

This decomposition is not exactly additive, as partial welfare changes do not add up to the total Δ^w and Δ^e. The addition discrepancy is only about $3-4\%$ though, which is low enough to make this decomposition useful. The results are in Table 4.

The welfare of the workers increases relative to the unregulated equilibrium, while that of the entrepreneurs decreases: $\Delta^w > 0$ and $\Delta^e < 0$. Welfare gains for workers mostly come from wages, while insurance properties of their portfolio deteriorate relative to the unregulated equilibrium. Welfare losses of entrepreneurs also come from wages and the exchange rates, and efficiency gains offset around a third of those. A less dollarized portfolio allows for more production of tradables. The impact of risk-sharing on entrepreneurs is small because they are risk-neutral in our example.

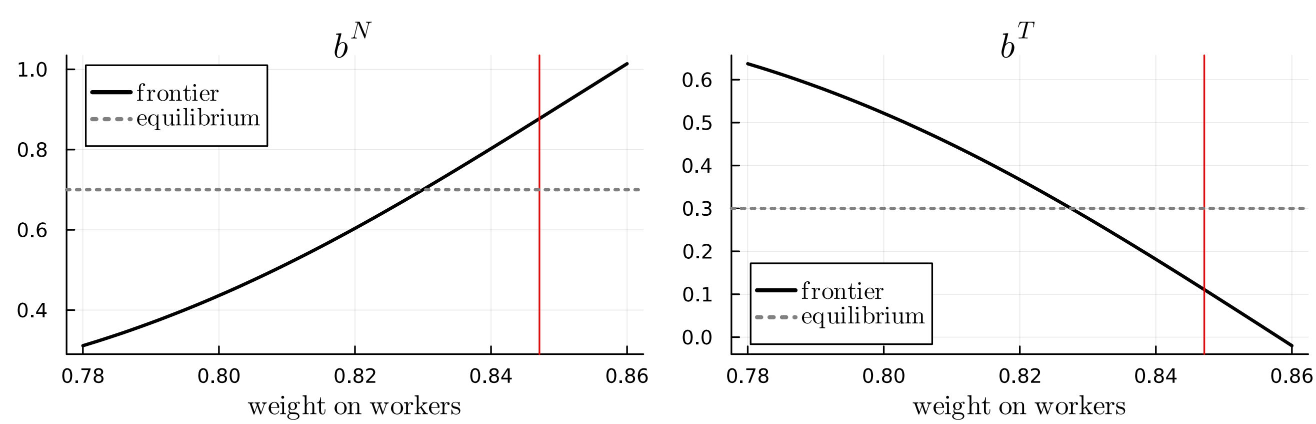
Table 4: decomposition of welfare increase for workers and entrepreneurs.

$\Delta^{\text{efficiency},w}/\Delta^w$	$\Delta^{\text{wage},w}/\Delta^w$	$\Delta^{\text{exchange rate},w}/\Delta^w$	$\Delta^{\text{risk-sharing},w}/\Delta^w$
0	116%	19%	−39%
$\Delta^{\text{efficiency},e}/\Delta^e$	$\Delta^{\text{wage},e}/\Delta^e$	$\Delta^{\text{exchange rate},e}/\Delta^e$	$\Delta^{\text{risk-sharing},e}/\Delta^e$
−34%	111%	17%	3%

F Pareto improvements and Pareto frontier

Pareto frontier can be traced out numerically. The social optimum we characterize in Section 3 is one point on the Pareto frontier that corresponds to a specific weight on workers. Figure 5 shows the optimal portfolio as a function of the weight the planner puts on workers. Dollarization of the savings portfolio decreases in the workers' weight.

Figure 5: Optimal debt as a function of the weight on workers. Red lines show the weight generating the social optimum from Section 3. Dashed lines show debt from the unregulated equilibrium.



We next deal with another point on the Pareto frontier. Specifically, we find the Pareto improvement that maximizes the workers' value. By definition, it leaves entrepreneurs exactly as well-off as the unregulated equilibrium.

We find that the space of Pareto improvements is quite narrow in our model. Dynamic externalities are tightly related to redistribution, Policies that benefit workers do so through increasing wages and strengthening the exchange rate since workers are net sellers of non-tradables. These gains are losses for entrepreneurs.

In the Pareto improvement that we consider, aggregate debt is lower and more dollarized. The expected repayment at $t = 1$ is 0.96 compared to 1.0 in the unregulated equilibrium, and dollarization is 51% compared to 30%. Repeating the analysis from Appendix E, we find that gains to workers come from redistribution through wages and exchange rates. Entrepreneurs take losses on wages and exchange rates, but these losses are compensated by making their portfolios more profitable. Table 5 presents the decomposition of welfare gains and losses analogous to that in Appendix E. The only difference is that here we divide by the value in the unregulated equilibrium to avoid division by zero in the entrepreneurs' case (their welfare change is zero).

Table 5: decomposition of welfare increase for workers and entrepreneurs.

$\Delta^{\text{efficiency},w}/\mathcal{V}^w$	$\Delta^{\text{wage},w}/\mathcal{V}^w$	$\Delta^{\text{exchange rate},w}/\mathcal{V}^w$	$\Delta^{\text{risk-sharing},w}/\mathcal{V}^w$
0	0.026%	0.003%	−0.027%
$\Delta^{\text{efficiency},e}/\mathcal{V}^e$	$\Delta^{\text{wage},e}/\mathcal{V}^e$	$\Delta^{\text{exchange rate},e}/\mathcal{V}^e$	$\Delta^{\text{risk-sharing},e}/\mathcal{V}^e$
0.033%	−0.18%	−0.017%	0.162%

We assess the strength of externalities at this Pareto improvement by computing the marginal benefits of decreasing the two types of debt and de-dollarization as in Section 4. Table 6 presents them alongside the values at the unregulated equilibrium and the social optimum.

Table 6: marginal benefits of intervention (in percentage points).

	$\mathcal{F}^T$	$\mathcal{F}^N$	$\mathcal{F}^\Delta$	$\mathcal{R}^T$	$\mathcal{R}^N$	$\mathcal{R}^\Delta$
unregulated equilibrium	0.77	0.68	0.08	10.03	9.10	0.88
Pareto improvement	0.94	0.82	0.11	8.57	7.69	0.83
social optimum	0.10	0.08	0.01	7.54	6.86	0.64

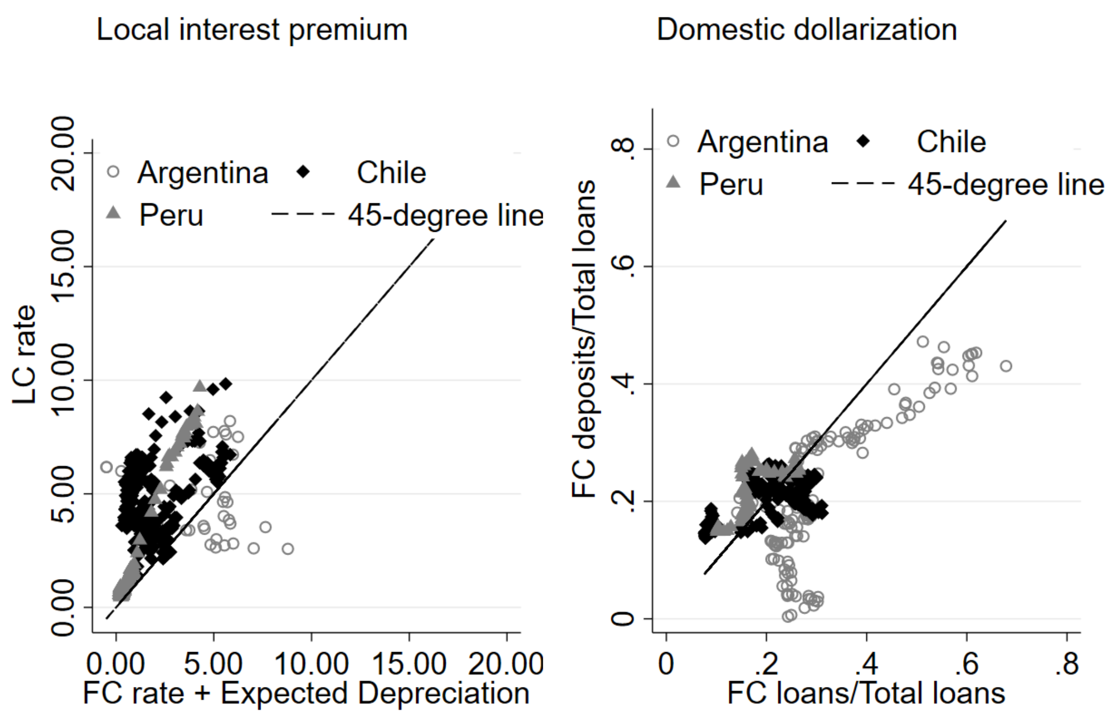
The marginal benefits $\mathcal{R}^T$, $\mathcal{R}^N$, and $\mathcal{R}^\Delta$ coming from redistributive motives are lower in the Pareto improvement case than in the unregulated equilibrium. It means that by implementing this Pareto improvement, the planner goes some way towards the optimum in terms of redistribution. In contrast, the marginal benefits $\mathcal{F}^T$, $\mathcal{F}^N$, and $\mathcal{F}^\Delta$ coming from decreasing amplification are higher than in the unregulated equilibrium. This indicates that the planner has to increase portfolio dollarization to make borrowing cheaper for entrepreneurs as compensation.

G Own calculations of standard facts and data sources

We revisit two well-known stylized facts related to internal financial dollarization. These are quoted in Bocola and Lorenzoni (2020a) and guide their modelling assumptions. We follow a similar approach to theirs, while also highlighting how our third fact appears in our model. These facts also set calibration targets for Section 4.

All our calculations use data for the period 2000-2018, while in some cases the time windows are shorter due to data availability. Data for our first two facts comes from national central banks.

Figure 6: Stylized facts about internal dollarization



Source: National Central Banks.

Fact 1: The domestic interest rate for foreign currency deposits is lower than that for local currency deposits after adjusting for expected depreciation.

The first panel in Figure 6 shows monthly data for passive interest rates for local currency instruments against the interest rate for comparable foreign currency instruments for Argentina, Chile, and Peru. To express everything in local currency we add expected annual depreciation to the interest rate for foreign currency instruments. The main takeaway is that households demand higher interest rates when saving in local currency than when saving in foreign currency, as can be seen from most data points lying above the 45 degree line.

Christiano et al. (2021) perform a similar analysis including more years and countries and arrive at the same conclusion. Compared to their analysis, we focus on saving instruments used by households and not on deposits more generally. We keep instruments with maturities of at least one year. The common reading of this premium is that households are willing to accept lower rates on foreign currency savings because these instruments have insurance properties that local currency savings do not. Gutierrez et al. (2021) provide support for this interpretation using detailed data from Peru. Bocola and Lorenzoni (2020a) also incorporate this channel.

Fact 2: The share of household deposits denominated in foreign currency matches the share of firm liabilities denominated in foreign currency.

The second panel of Figure 6 shows monthly data for the share of household deposits that are denominated in foreign currency against the share of loans to firms denominated in foreign currency (both are stock variables). It is clear from the figure that domestic banks match deposits denominated in dollars to loans denominated in dollars. As discussed in Christiano et al. (2021), this pattern is partly driven by regulation requiring domestic banks to match the currency composition of their balance sheets. The main takeaway is that domestic households' demand for assets denominated in foreign currency is largely provided by domestic firms. In our analysis, this fact motivates modelling firms as borrowing directly from households.

Data sources. For Figure 1, we use data from the IMF Macroprudential Policies Database. We code a binary variable that takes value 1 if a country in a given year has tightened their LFC or LFX positions, and then sum across countries.

In Figure 2 we use data from the Argentinean, Chilean and Peruvian Central Banks. Regarding rates, our goal is to gather the rates on comparable instruments for which there are options both in local and foreign currency. Our decision over which instrument to pick is guided by the model and what we want to capture, the savings of representative households. In all cases we use expected depreciation of the domestic currency from survey data provided by the same central banks.

For Argentina, when calculating deposit dollarization we keep deposits made by natural persons from the private sector. When calculating loans we only keep loans taken by legal persons (firms) net of mortgages and car loans. For interest rates, we keep passive rates on time deposits of maturities higher than 60 days. We net out expected depreciation one year ahead the month we are considering. The Argentinean data for interest rates starts in 2004. The period between 2007 and 2015 included intervention of the statistics institute and stark control on capital outflows, making the observations for rates during this period not so useful for our purposes. We therefore drop these years.

For Chile, when calculating deposit dollarization and loans we keep deposits with maturity longer than a month (because for foreign currency deposits we do not have a finer disaggregation) and commercial loans. For passive interest rates from deposits we consider maturities from 1 to 3 years. We keep all years between 2001 and 2019.

For Peru, we keep deposits and loans for the private sector. For interest rates, we keep passive interest rate for 'savings'. We do not use data for longer maturities because they start only from 2010.