Time-Consistent Optimal Interventions: Recapitalization versus Debt Dilution

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Abstract

This paper studies optimal policies to accelerate corporate recapitalization during tight financial conditions. The policymaker can finance the recapitalization program through income taxes; however, households operating the labour-intensive production technology can evade their tax obligations. An inflation tax can also facilitate recapitalization by reducing the actual value of nominal domestic currency external debt. The inflation tax distorts the labour market and increases menu costs and the real foreign currency external debt as the exchange rate depreciates faster than prices rise. Despite all these costs, partially imposing an inflation tax on foreign lenders rather than only collecting income taxes from households becomes welfare-improving. Raising an inflation tax further as tax evasion grows is also optimal. However, anticipated debt dilution tilts corporations to increase foreign currency debt, permitting cheaper investment financing but raising exposure to currency risks. Pecuniary externalities generate scope for macroprudential policies, alleviating the effects of financial shocks.

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1 Introduction

Emerging market financial crises can lead to tremendous economic damage, necessitating government interventions. Financing large-scale interventions under tax evasion is a considerable challenge for emerging world policymakers.[1] Thus, I first study the optimal way to accelerate corporate recapitalization during tight financial conditions under tax evasion, then the effects of anticipated government policies on the currency composition of external debt. Imposing an inflation tax on foreign lenders rather than only collecting income taxes from households becomes welfare-improving despite strong currency mismatch effects. Anticipated domestic currency debt dilution risks tilt corporations to increase foreign currency debt, permitting cheaper investment financing but raising exposure to currency risks.

The effectiveness of bailouts in accelerating the recovery from a crisis has become the central issue of the ongoing policy debate. On the one hand, bailouts accelerate capital formation in a crisis (Bianchi, 2016). On the other hand, anticipated bailouts lead to excessive debt accumulation in pre-crisis (Farhi and Tirole, 2012). They can also undermine the government's fiscal capacity, reflecting the private sector (Farhi and Tirole, 2017). However, a labour-intensive production sector, enabling tax evasion, omitted in this influential literature, may lead to tighter government budget constraints during recapitalization as agents working in this sector evade their tax obligations.

In addition, excessive foreign currency debt accumulation in the non-tradable sector, where revenue depends on the exchange rate but not debt, magnifies financial fragility (Schneider and Tornell, 2004; Kalantzis, 2015). When anticipating bailouts, corporations in the non-tradable sector find extending the share of foreign currency debt is optimal. By doing so, they shift debt repayment to taxpayers (Schneider and Tornell, 2004). However, taxing households to finance bailouts under tight financial conditions is highly costly and, more significantly, shifts workers from more productive to less productive labour-intensive

[1] In particular, the informal economy's average share is about 34% of GDP, as reported in Table 1. While tax evasion is also a challenge for advanced economies, it is relatively small in these countries. Thus, I focus on the emerging world.

sectors, undermining recapitalization. Considering these effects, this paper studies whether policymakers should partially tax foreign lenders through an inflation tax rather than only taxing households under a tight financial regime.

This paper studies a DSGE model incorporating the above-mentioned issues. The model is a small open economy akin to Bianchi (2016). Households receive tradable endowments each period and supply labour to corporations or operate a labour-intensive production technology to produce non-tradable goods. Households working in corporations pay income taxes to the government, but households operating the labour-intensive production technology can evade their tax obligations at no cost (Koreshkova, 2006; Amaral and Quintin, 2006). They are also shareholders of corporations, thereby receiving dividend payments each period.

Corporations produce non-tradable goods under nominal and financial frictions.[2] They issue one-period foreign and domestic currency bonds in international markets and raise household equity to finance investment. While foreign currency bonds are risk-free for lenders, domestic currency bond yields are contingent on dilution risks.[3] Corporations are subject to currency mismatch risk since they hold foreign currency debt but earn domestic currency revenue.[4] A crisis occurs when external borrowing and domestic equity market constraints bind (Bianchi, 2016). A tight domestic equity constraint generates a more considerable investment drop since corporations would otherwise finance investment by raising equity.

In competitive equilibrium, I first consider the case where the policymaker can not intervene to recapitalize corporations and stabilize inflation to show the marginal effects of optimal government policies later. Then, I allow the policymaker to choose only inflation optimally, thereby domestic currency depreciation. A domestic currency depreciation's costs

[2]Focusing on the non-tradable sector production is not a restrictive assumption. It is consistent with the fact that this sector accounts for a high share of output in emerging countries. The results would still carry through with a tradable sector as long as a significant fraction of corporations suffer from the currency mismatch effects. Besides, domestic currency depreciation is less damaging for tradable sector corporations with natural hedges through foreign currency revenues.

[3]I abstract from the corporate default risk. Even if I extended the model with outright default, the results indicating the trade-off related to inflation and income taxes would still carry through. The default option only captures repayment/default decision depending on the total outstanding debt.

[4]Non-exportable corporations do generally not hedge their exposure to currency risks through financial instruments (Salomao and Varela, 2021).

outweigh its benefits; in that case, the optimal policy embraces the fear of floating argument. In other words, it is optimal to allow more negligible depreciation.

Households cannot internalize that the future benefits of transferring resources to corporations in a tight credit regime outweigh its contemporaneous costs. This inefficiency generates scope for government interventions. Thus, I study the case that the policymaker can recapitalize corporations through income taxes to show the relative effects of an inflation tax later. While taxing households to finance interventions in a crisis is very costly, accelerating recapitalization raises future wages and dividend payments. Besides, higher capital accumulation in the formal sector leads to rarer informal economic activities. Hence, the quantitative analysis shows that future benefits surpass contemporaneous costs.

I then consider the case where the policymaker can finance recapitalization through income taxes and impose an inflation tax on foreign lenders to reduce nominal debt's actual value. Heavily relying on an inflation tax is also challenging, but the policymaker finds it optimal to partially shift the tax burden from income taxes to an inflation tax. Thus, adding the inflation tax as a policy tool significantly reduces households' tax burden. This policy is desirable since an inflation tax facilitates the transfer of resources from unproductive to productive sectors. Raising an inflation tax further as tax evasion grows is also optimal. Thus, supplementing fiscal and monetary policies is crucial for alleviating a crisis under tax evasion.

When international lenders recognize dilution risks, they require higher yields for domestic currency bonds. Then, corporations face a trade-off between higher exposure to currency risks and more expensive investment financing. Consequently, they tilt the currency composition to foreign currency. As a result, the policymaker inevitably intervenes to recapitalize corporations when an adverse shock hits the economy, shifting debt repayment to taxpayers. In that case, balancing the cost of distortionary policy tools in accelerating recapitalization becomes optimal rather than relying on only one policy tool. While anticipated dilution risks grow exposure to currency risks, cheaper investment financing accelerates capital accumula-

tion, increasing the resilience of corporations to currency risks in the future.

Expanding government demand for non-tradable goods can also relax constraints since higher demand raises the relative price of non-tradable goods. However, financing government expenditures through income taxes in a crisis is only sometimes optimal. Besides, taxing capital inflows in foreign currency can limit ex-ante risk-taking.

Relation to the Literature. This paper builds on the recent sudden stop literature as in Mendoza (2010). In particular, I study optimal policies by addressing non-linear dynamics with occasionally binding constraints as in Bianchi (2016).

The paper also relates to the theoretical literature studying interventions' ex-post implications on financial stability. Keister (2016) states that commitment to a no-bailout policy accelerates bank-runs. Chari and Kehoe (2016) propose that it is optimal to bail out firms to avoid bankruptcy costs. Bianchi (2016) contributes that domestic equity and external borrowing constraints generate scope for interventions since the production sector can not finance the desired level of investment in a crisis. While these papers make influential theoretical contributions to the desirability of interventions, they are silent about the government's fiscal capacity to finance them under tax evasion.

Schneider and Tornell (2004); Kalantzis (2015) show that, as the non-tradable sector becomes growingly exposed to exchange rate risks, the economy becomes more fragile to crises. The other notable implication of this literature is that it is optimal for non-tradable sector corporations to raise their share of foreign currency debt when they anticipate bailouts. Accordingly, they raise the probability of triggering bailouts in a crisis, shifting debt repayment to taxpayers. However, this paper contributes to this influential literature by showing that debt dilution temptations in emerging market economies are also crucial under tax evasion, not only anticipated bailouts. Besides, this paper finds optimal policies under occasionally binding financial constraints.

Koreshkova (2006) shows that an informal sector is essential in explaining why inflation persists in developing countries. She shows that governments tend to monetize expenditures

as the informal economy grows. However, she does not incorporate a crisis and the private sector's high foreign currency debt in the quantitative analysis. Abstracting from the currency mismatch effects leads to underestimating inflation costs and raises the temptation to monetize government expenditures. Besides, Jiao (2020) supposes that the policymaker can only implement an inflation tax and shows that monetizing interventions is optimal. However, this result holds only under such a restrictive assumption about the government policy toolkit. This paper significantly differs from the previous literature by showing that an inflation tax should supplement income taxes to alleviate a crisis. Besides, this paper contributes that an anticipated inflation tax leads to shifts in the currency composition of liabilities under tax evasion, dramatically influencing the exposure to currency risks.

2 Model

2.1 Households

There exists a continuum of identical households of unity mass. The lifetime preferences of the representative household are

$$\underset{c_t^T, c_t^N, h_t^s}{max} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \chi \frac{(h_t^s)^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} \tag{1}$$

where $\mathbb{E}$ is the expectations operator. β is the subjective discount factor, σ denotes the constant relative risk aversion, χ is the labor disutility coefficient, and ν represents the inverse Frisch elasticity. h_t^s is labor supply and c_t denotes consumption that is a CES index of tradable c_t^T and non-tradable c_t^N goods

$$c_t = \left[a \left(c_t^T\right)^{1-\frac{1}{\xi}} + (1-a) \left(c_t^N\right)^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}}$$

ξ is the elasticity of substitution between tradable and non-tradable goods and a shows the share of tradable goods in consumption. Total labor supply is allocated between the formal

h_t and informal h_t^I sectors

$$h_t^s = h_t + h_t^I \tag{2}$$

Each period households receive stochastic tradable endowments y_t^T. The non-tradable sector is the production sector, and non-tradable goods are produced both in the formal and informal sectors. In particular, households can operate the following unofficial labor-intensive production technology (Koreshkova, 2006)

$$f(h_t^I) = (z^I h_t^I)^{\alpha_h^I}$$

where z^I is a scale parameter. The unofficial production technology exhibits decreasing returns to scale.

Households are shareholders of corporations and receive dividend payments d_t and nominal wages W_t. Households working in the formal sector pay income taxes τ_t to the government, but earnings from informal production are concealed from authorities' detection at no cost. The representative agent's budget constraint in nominal terms is

$$P_t^T c_t^T + P_t^N c_t^N = P_t^T y_t^T + (1-\tau_t) W_t h_t + P_t^T d_t + P_t^N f(h_t^I)$$

where P_t^T (P_t^N) is the price of tradable (non-tradable) goods. The foreign currency price of tradable goods $P_t^{T^*}$ is normalized to unity. The law of one price holds for tradable goods

$$P_t^T = P_t^{T^*} \epsilon_t = \epsilon_t$$

where ϵ_t shows the nominal exchange rate. The domestic currency depreciation is

$$e_t = \frac{\epsilon_t}{\epsilon_{t-1}} = \frac{P_t^T}{P_{t-1}^T}$$

The budget constraint in terms of tradable goods is

$$c_t^T + p_t^N c_t^N = y_t^T + (1-\tau_t) w_t h_t + d_t + p_t^N f(h_t^I) \tag{3}$$

where $p_t^N = \frac{P_t^N}{P_t^T}$ and $w_t = \frac{W_t}{P_t^T}$ denote the relative price of non-tradable goods and wages in terms of tradable goods.

The representative household maximizes the lifetime utility (Equation 1) subject to time (Equation 2), and budget (Equation 3) constraints. The intratemporal consumption Euler gives the relative price of non-tradable goods as a function of consumption allocations

$$p_t^N = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{\frac{1}{\xi}} \tag{4}$$

2.2 Non-Tradable Sector

A continuum of corporations produces intermediate goods in a monopolistic competitive environment. Final good producers competitively aggregate intermediates into a consumption composite.

2.2.1 Corporations

There exists a continuum of corporations, indexed by $j \in [0,1]$, and each corporation produces a specific variety y_{jt}^N by using labor h_{jt} and physical capital k_{jt}

$$y_{jt}^N = k_{jt}^{\alpha_k}\left(z^F h_{jt}\right)^{\alpha_h^F} \tag{5}$$

where α_k, α_h^F show the shares of capital and labor. z^F is a scale parameter.

Each corporation starts the current period with capital k_{jt} and invests i_{jt}, but capital accumulation is subject to the quadratic adjustment cost

$$\frac{a_k}{2}\left(\frac{k_{jt+1}}{k_{jt}} - 1\right)^2 k_{jt}$$

where a_k is the adjustment cost parameter. The capital adjustment cost makes a crisis costlier by taking some real resources during disinvestment. Besides, it dampens investment volatility, thereby improving the quantitative performance of the model. Capital accumulation technology is given as

$$i_{jt} = k_{jt+1} - (1-\delta)k_{jt} + \frac{a_k}{2}\left(\frac{k_{jt+1}}{k_{jt}} - 1\right)^2 k_{jt} \tag{6}$$

where δ denotes the depreciation rate.

Each corporation has foreign b^*_{jt} and domestic b_{jt} currency external debt and issues b^*_{jt+1} and b_{jt+1} at prices q^*_t and q_t in international markets. Borrowing in foreign currency requires an additional cost (Aoki, Benigno, and Kiyotaki, 2016; Salomao and Varela, 2021). Besides, the cost increases with the share of a foreign currency debt quadratically (Bacchetta and van Wincoop, 2021)[5]

$$\psi\left(b^*_{jt+1}, b_{jt+1}\right) = \frac{a_b}{2}\left(\frac{b^*_{jt+1}}{b^*_{jt+1}+b_{jt+1}} - \frac{b^*_t}{b^*_t+b_t}\right)^2$$

where a_b is the adjustment cost parameter.

Corporations can also reset the price of intermediate goods each period, but resetting the price P_{jt} of a variety j is subject to the quadratic adjustment cost (Rotemberg, 1982)

$$\frac{a_p}{2}\left(\frac{P^N_{jt}}{P^N_{jt-1}} - \pi^N\right)^2$$

where π^N is the inflation target. a_p is the adjustment cost parameter. The price adjustment cost slows the price rise, generating currency mismatch as the domestic currency depreciates faster than the price increase.

Each corporation makes dividend payments d_{jt} to shareholders. Besides, the government may recapitalize each corporation T_{jt} in a crisis. The flow budget constraint in terms of tradable goods is then

$$\begin{aligned} d_{jt} + b^*_{jt} + \frac{b_{jt}}{e_t} + i_{jt} = (1+\tau_y)\frac{P^N_{jt}}{P^T_t}y^N_{jt} - w_t h_{jt} + q^*_t b^*_{jt+1} + q_t b_{jt+1} - \frac{a_p}{2}\left(\frac{P^N_{jt}}{P^N_{jt-1}} - \pi^N\right)^2 \\ -\psi\left(b^*_{jt+1}, b_{jt+1}\right) + T_{jt} - \tau_y p^N_t y^N_t \end{aligned} \tag{7}$$

$\tau_y = \frac{1}{\gamma-1}$ is the output subsidy that corrects distortions due to monopolistic competition (Rotemberg and Woodford, 1999), where $\gamma > 1$ shows the elasticity of substitution among different varieties. Revenue generated by imposing lump-sum taxes on all corporations funds

[5]Portfolio adjustment costs make domestic and foreign currency bonds imperfect substitutes, generating a downward sloping demand curve. Thus, the optimal share adjusts by a finite amount according to anticipated dilution risks. Thereby, this function improves the model's numerical stability. Besides, the results related to the trade-offs between inflation and income taxes persist with/without portfolio adjustment costs. Thus, this function does not affect the model's implications.

subsidy payments.[6]

Total debt is limited not to exceed the stochastic fraction κ_t of investment

$$q_t^* b_{jt+1}^* + q_t b_{jt+1} \leq \kappa_t k_{jt+1} \tag{8}$$

The financial shock significantly improves the quantitative performance of DSGE models by closely capturing the key macro facts around a Sudden Stop episode (Mendoza, 2010). In addition, this shock reflects the disruptions in the financial intermediation process such that intermediaries may become more limited in lending resources to the private sector or restrict lending because of the risks in the private sector (Christiano, Motto and Rostagno, 2014).

Domestic financial frictions also limit corporations' capacity to finance investment

$$\underline{d} \leq d_{jt} \tag{9}$$

where $\underline{d}$ shows the lowest bound on dividend payments (Bianchi, 2016). The binding external borrowing constraint pressures corporations to diminish dividend payments to shareholders. However, dividend constraint prevents corporations from reducing dividend payments below the lowest bound, forcing them to cut down investment further.[7]

Let $s_t \equiv \{z_t, r_t, \kappa_t\}$, K_t, B_t^*, B_t denote exogenous states, aggregate capital, aggregate foreign and domestic currency bond holdings. Then, the aggregate state vector is expressed as $S_t \equiv \{s_t, K_t, B_t^*, B_t\}$. Let k_{jt}, b_{jt}^* and b_{jt} denote each corporation's private capital and bond holdings. Since households own corporations, let $n(S_t, S_{t+1})$ show the stochastic discount factor of the household. Besides, let $W(k_{jt}, b_{jt}^*, b_{jt}, S_t)$ denote the dividend market value of a corporation. Each corporation chooses allocations to maximize the shareholder value given prices, government policies, and the output subsidy

$$W\left(k_{jt}, b_{jt}^*, b_{jt}, S_t\right) = \max_{\Psi_t} \left\{ d_{jt} + \mathbb{E}_t n\left(S_t, S_{t+1}\right) W\left(k_{jt+1}, b_{jt+1}^*, b_{jt+1}, S_{t+1}\right) \right\}$$

[6]The policymaker could also finance the subsidy through distortionary taxation. In that case, the model would still produce very similar results.

[7]I also define costly equity adjustment instead of a dividend constraint. However, the paper's main message still carries through as long as corporations have a limited borrowing capacity and tax evasion undermines the government's financial capacity to fund recapitalization. See the appendix for the other formulation of domestic financial frictions.

where $\Psi_t \equiv \{d_{jt}, h_{jt}, k_{jt+1}, b^*_{jt+1}, b_{jt+1}, P^N_{jt}\}$ and subject to capital accumulation (Equation 6), budget (Equation 7), borrowing (Equation 8), and dividend (Equation 9) constraints.

2.2.2 Final Goods Producers

Final good producers use Dixit-Stiglitz aggregation technology to produce a composite good y^N_t from intermediate goods

$$y^N_t = \left[\int_0^1 \left(y^N_{jt}\right)^{\frac{\gamma-1}{\gamma}} dj\right]^{\frac{\gamma}{\gamma-1}}$$

The aggregate price is then given by

$$P^N_t = \left[\int_0^1 \left(P^N_{jt}\right)^{1-\gamma} dj\right]^{\frac{1}{1-\gamma}}$$

Cost minimization gives the optimal demand for each variety j

$$y^N_{jt} = \left(\frac{P^N_{jt}}{P^N_t}\right)^{-\gamma} y^N_t$$

2.3 International Lenders

There exists a continuum of identical risk-neutral international lenders. They have perfect information regarding the economy's fundamentals, behave competitively and expect zero profit at equilibrium. They can either invest in foreign currency risk-free international assets that pay net real returns r_t or corporate bonds. Lenders are indifferent between the foreign currency corporate bond and the risk-free asset. However, the domestic currency corporate bond is risky since the policymaker can lower its actual value by allowing a substantial domestic currency depreciation. Lenders internalize this incentive. Thus, the domestic currency bond price depends on the dilution risks at the equilibrium such as

$$q^*_t = \frac{1}{1+r_t}, \quad q_t = \frac{1}{1+r_t}\mathbb{E}_t\left[\frac{1}{e_{t+1}}\right] \tag{10}$$

2.4 Government

The policymaker determines income taxes τ_t, inflation in the non-tradable sector π_t^N, recapitalization T_t, and government expenditures g_t^N. To see how expansionary fiscal policies also support the relative price of non-tradable goods, thereby relaxing corporate balance sheets, plug in the market clearing condition for non-tradable goods into Equation 4

$$\uparrow p_t^N = \frac{1-a}{a}\left(\frac{c_t^T}{y_t^N + f(h_t^I) - \uparrow g_t^N}\right)^{\frac{1}{\xi}}$$

The government's budget constraint is given by

$$p_t^N g_t^N + T_t \leq \tau_t w_t h_t$$

2.5 Competitive Equilibrium

In the competitive equilibrium, I suppose that the policymaker sets government expenditures, income taxes, and recapitalization to zero and stabilizes inflation to show each policy's relative effectiveness in the following section such that

$$g_t^N = \tau_t = T_t = 0, \quad \pi_t^N = \pi^N$$

The aggregate resource constraint for tradable goods obtained by combining the household's budget constraint with that of the corporation and government is

$$c_t^T + b_t^* + \frac{b_t}{e_t} + i_t = y_t^T + q_t^* b_{t+1}^* + q_t b_{t+1} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 - \psi\left(b_{t+1}^*, b_{t+1}\right) \tag{11}$$

The resource constraint for non-tradable goods is

$$c_t^N + g_t^N = y_t^N + f(h_t^I) \tag{12}$$

Definition 1 (**The Recursive Competitive Equilibrium**). *Given exogenous* $s_t \equiv \left\{y_t^T, r_t, \kappa_t\right\}$ *and aggregate* $S_t \equiv \{s_t, K_t, B_t^*, B_t\}$ *states, government policies* $\Omega(S_t) \equiv \left\{\tau_t, \pi_t^N, g_t^N, T_t, e_t\right\}$, *and the output subsidy* $\tau_y = \frac{1}{\gamma - 1}$, *the recursive competitive equilibrium consists of the equity value* $W(k_t, b_t^*, b_t, S_t)$ *of the representative corporation, the stochastic discount factor* $n(S_t, S_{t+1})$, *policy functions of the household's problem* $\hat{c}(S_t; \Omega(S_t))$, $\hat{c}^T(S_t; \Omega(S_t))$, $\hat{c}^N(S_t; \Omega(S_t))$,

$\hat{h}(S_t;\Omega(S_t))$, $\hat{h}^I(S_t;\Omega(S_t))$, *policy functions of the corporation's problem* $\hat{d}(S_t;\Omega(S_t))$, $\hat{h}(S_t;\Omega(S_t))$, $\hat{b^*}'(S_t;\Omega(S_t))$, $\hat{b}'(S_t;\Omega(S_t))$, $\hat{k}'(S_t;\Omega(S_t))$, *prices* $\hat{p}^N(S_t;\Omega(S_t))$, $\hat{w}(S_t;\Omega(S_t))$, $\hat{q}^*(S_t;\Omega(S_t))$, $\hat{q}(S_t;\Omega(S_t))$, $\hat{\eta}(S_t;\Omega(S_t))$, $\hat{\mu}(S_t;\Omega(S_t))$, *and the law of motion of the aggregate variables* $S_{t+1} = \Lambda(S_t)$ *such that*

1. *Policy functions* $\hat{c}(S_t;\Omega(S_t))$, $\hat{c}^T(S_t;\Omega(S_t))$, $\hat{c}^N(S_t;\Omega(S_t))$, $\hat{h}(S_t;\Omega(S_t))$, $\hat{h}^I(S_t;\Omega(S_t))$ *solve the household's problem.*

2. *Policy functions* $\hat{d}(S_t;\Omega(S_t))$, $\hat{h}(S_t;\Omega(S_t))$, $\hat{b^*}'(S_t;\Omega(S_t))$, $\hat{b}'(S_t;\Omega(S_t))$, $\hat{k}'(S_t;\Omega(S_t))$ *solve the corporation's recursive problem.*

3. *Prices clear goods and labor markets.* $\hat{\mu}(S_t;\Omega(S_t))$ *and* $\hat{\eta}(S_t;\Omega(S_t))$ *are associated with borrowing and equity constraints.*

4. *Resource constraints hold.*

5. *The law of motion of aggregate variables is consistent with individual states and the stochastic processes.*

6. *The government budget constraint holds.*

2.6 Constrained Efficiency

I now highlight inefficiencies in the competitive equilibrium, leading to undercapitalization in a crisis and calling for government interventions. Unlike private agents, the social planner recognizes how prices affect the dividend constraint's tightness. The planner acknowledges that it can turn prices in favor of the representative corporation's balance sheet. The planner's problem is subject to resource constraints, implementability constraints, and competitive equilibrium prices such that goods and labor markets clear competitively. Since the policymaker stabilizes inflation in the competitive equilibrium, I abstract from nominal frictions to show the pecuniary externalities. I also recap from the informal sector and

portfolio choice.[8]

Definition 2 (**Constrained Efficiency**). *The planner maximizes the representative household's utility*

$$\max_{\Gamma_t} \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma}$$

where $\Gamma_t \equiv \left\{c_t, c_t^T, c_t^N, h_t, k_{t+1}, b_{t+1}^*\right\}_{t=0}^{\infty}$ *and subject to*

1. *the market clearing condition for tradable goods*

$$c_t^T + b_t^* + i_t = y_t^T + q_t^* b_{t+1}^*$$

2. *the market clearing condition for non-tradable goods*

$$c_t^N = y_t^N$$

3. *the collateral constraint*

$$q_t^* b_{t+1}^* \leq \kappa_t k_{t+1}$$

4. *the dividend constraint*

$$\underline{d} \leq d_t^{SP} = p_t^N y_t^N - w_t h_t - i_t - b_t^* + q_t^* b_{t+1}^*$$

5. *competitive equilibrium prices* q_t^*, p_t^N *and* w_t.

The following first-order condition clarifies the distinction between the competitive equilibrium and social planner allocations.

$$c_t^T :: \quad u'(t)\frac{dc_t}{dc_t^T} - \lambda_t + \underbrace{\eta_t \left(y_t^N \frac{dp_t^N}{dc_t^T} - \frac{dw_t}{dc_t^T} h_t\right)}_{Externality} = 0$$

where λ_t and η_t show the Lagrangian multipliers associated with the resource constraint for tradable goods and the dividend constraint. Private agents take competitive equilibrium

[8] Inefficiencies still carry through with these extensions, but they noise the normative analysis unnecessarily. This section aims to reveal inefficiencies as simply as possible.

prices as given and can not recognize how their consumption choices affect prices. However, the planner recognizing these inefficiencies adjusts consumption accordingly. Private agents can not also internalize how labor demand affects prices such that

$$h_t :: \quad u'(t)\left(\frac{dc_t}{c_t^N}\frac{dc_t^N}{dh_t} - \chi h_t^{\nu}\right) + \underbrace{\eta_t\left(\frac{dp_t^N}{dy_t^N}\frac{dy_t^N}{dh_t}y_t^N + \alpha_h\frac{p_t^N y_t^N}{h_t} - \frac{dw_t}{dh_t}h_t - w_t\right)}_{Externality} = 0$$

These externalities result in market failure. However, they justify government interventions.

While financing bailouts through lump-sum taxes completely resolves these externalities, I suppose that lump-sum taxes are infeasible or that their political costs prevent the policymaker from implementing them.

Corollary 2.1. *When lump-sum taxes are available, the policymaker can replicate the social planner equilibrium by transferring resources to the corporation's balance sheet such that* $T_t = d_t^{SP} - d_t$.

2.7 Time-Consistent Optimal Policies

The policymaker lacks commitment to its future policies and decides each period given its future-self policies. I find the fixed point of policies representing the current and future policymakers. Interventions alleviate corporations' under-capitalization in a crisis but must be limited to moderate ex-ante effects. However, an ex-ante promise to eliminate ex-post intervention expectations is not credible since the policymaker finds it optimal to intervene when an adverse financial shock hits the economy. Thus, I focus on time-consistent policies.

Definition 3 (**Time-Consistent Optimal Policies**). *The policymaker maximizes the representative agent's utility each period, given its future self's perceived policy functions.*

$$V(S_t) = \max_{\Psi_t}\left\{u(c_t, h_t^s) + \beta\mathbb{E}_t V\left(S_{t+1}\right)\right\}$$

where $\Psi_t \equiv \left\{c_t, c_t^T, c_t^N, h_t, h_t^I, d_t, k_{t+1}, b_{t+1}^*, b_{t+1}, g_t^N, \tau_t, \pi_t^N, e_t, T_t\right\}$

1. *subject to competitive equilibrium conditions,*

2. perceived policies coincide with actual policies.

3 Quantitative Analysis

3.1 Solution Method

Due to the occasionally binding constraints, the model must be solved by global solution methods in discrete state space as in Mendoza (2010). I solve the competitive equilibrium allocations by policy function iteration and optimal time-consistent policies by value function iteration and approximate policy functions outside grid points by cubic B-splines. Parameter values match model moments with their empirical counterparts in the annual data of a typical emerging market economy from 1980 to 2020. The results are qualitatively robust to parameter variations.

3.2 Calibration

I estimate the transition probabilities of the tradable endowment and the interest rate by the simulation method. The tradable sector consists of agriculture, forestry, manufacturing, and mining. I compute the real interest rate as the sum of EMBI-spread and US Treasury bill rates adjusted by inflation expectations. Financial shocks are orthogonal to the tradable endowment and the interest rate, and select two values for the financial shock: high and low states. I ensure that the external borrowing constraint is slack in the high borrowing regime but may bind in the low borrowing regime. The low borrowing regime only appears when the tradable endowment is low, and the interest rate is high, consistent with the current account reversal periods. The probability of switching from the high borrowing regime to the low one targets two sudden stop episodes, and the low borrowing regime lasts a year.

I set the relative risk aversion parameter σ to 2 and the inverse of the Frisch elasticity of labor supply ν to unity in line with the literature. The capital α_k and labor α_h^F shares in the formal sector are set to 0.36 and 0.64, respectively. I set the labor share parameter α_h^I in

the informal sector to 0.72 as consistent with the informal economy literature (Koreshkova, 2006). I target the price markup of 11% as in the New Keynesian literature, thereby setting the elasticity of varieties γ to ten. β and δ target capital/output and investment/output ratios. I set z^F to normalize the official non-tradable goods to unity and z^I to equate the informal economy/GDP ratio to 0.32. a_k (a_p) captures the standard deviation of the investment/output ratio (inflation in the non-tradable sector), and a matches the share of tradable goods in aggregate consumption. a_b approximates the portfolio adjustment costs. I stick to the widespread limited liability constraint and set $\underline{d}$ to zero.[9] Table 2 reports all parameter values.

3.3 Results

I first reveal the effects of domestic financial frictions on model dynamics. Figure 1 shows the equilibrium law of motions for total debt and capital in the next period as a function of current debt. Total debt in the next period increases with current debt with/without the dividend constraint in the high external borrowing regime. In contrast, capital strictly diminishes with current debt in the next period, even in the high borrowing regime, since high debt levels significantly raise the probability of future binding constraints. That discourages corporations from increasing investment financed through borrowing.

The quantitative analysis shows that the borrowing constraint binds first. While tight borrowing capacity leads to a sudden reversal in policy functions, the binding equity constraint induces more notable discrepancies. The binding dividend constraint prevents corporations from raising new equity to finance investment when the borrowing capacity contracts. Since households can not internalize that resources are more valuable within corporations in the tight credit regime, they are unwilling to transfer resources to corporations. This inefficiency calls for government intervention.

To display the relative effectiveness of optimal policies, I first solve the competitive equi-

[9]The results persist when corporations can raise equity revenue without entirely relaxing the borrowing constraint such as $\underline{d} = -0.02$

librium as a benchmark and then find optimal policies. The policymaker can intervene to recapitalize corporations or expand expenditure for non-tradable goods to support the relative price. First, policymakers can finance these interventions only through income taxes. After that, I incorporate an inflation tax into the quantitative analysis to reveal the effects of supplementing fiscal policy with monetary policy on model dynamics.

Figure 2 compares the equilibrium law of motions of the competitive equilibrium and the policymaker's problem with optimal inflation and recapitalization. When the policymaker only chooses inflation, allowing a more negligible inflation and domestic currency depreciation is optimal. Depreciation significantly increases the foreign currency external debt burden as the exchange rate depreciates faster than prices rise. Nominal rigidities and domestic financial frictions call for a more conservative depreciation policy. Therefore, with very low domestic currency debt, the results are consistent with the predictions of the fear of floating argument. Besides, when recapitalization is available, transferring resources to corporations relaxes the dividend constraint, thereby accelerating recapitalization. While taxing households to finance recapitalization is very costly when the marginal utility of consumption is high, the recapitalization program accelerates capitalization, raising future wages and dividend payments. Thus, future benefits compensate for current costs.

With a moderate domestic currency debt share, since financing recapitalization in a crisis is very costly, the policymaker finds it optimal to shift the tax burden from households to foreign lenders partially. Adding an inflation tax to the quantitative analysis reduces households' tax burden. In other words, the policymaker can shift resources from unproductive to productive sectors through an inflation tax. Hence, despite strong balance sheet effects, it is optimal to partly rely on an inflation tax in urgent need of resources for domestic use. Lowering income taxes also moderates the labour movement from the formal to the informal sector. Instead of only relying on one policy tool, implementing all available policy tools to keep resources in the productive sector is optimal.

To demonstrate the role of an informal sector in competitive equilibrium, I recalibrated

the informal production technology parameter to lower the informal economy's share. In particular, I decreased the share of the informal economy as a percentage of GDP from 0.32 to 0.28. Now, Figure 3 compares the equilibrium law of motions under low and high shares of the informal economy and represents the policy functions of the competitive equilibrium and the policymaker's problem with optimal inflation and recapitalization. As the productivity of the informal technology grows, labour further accumulates in this sector, lowering the marginal productivity of capital in the official sector. As corporations find investment less profitable, external borrowing capacity shrinks. In other words, higher informal economic activities lead to higher resource accumulation in the less productive sector.

Figure 4 denotes the percent change in the currency composition of foreign liabilities with recapitalization compared to the competitive equilibrium. The results show that monetizing recapitalization leads corporations to raise the foreign currency debt share significantly. When monetization becomes very likely, corporations start to raise the foreign currency debt share even if the dividend constraint is slack. When lenders anticipate dilution risks, they require higher domestic currency bond yields. Thus, corporations tend to borrow more in foreign currency as dilution becomes likely. However, cheaper investment finance accelerates capital accumulation and makes corporations more resilient to currency risks in the future.

The policymaker can also relax corporations' balance sheets by expanding expenditure on non-tradable goods. This policy expands demand, raising the relative price. However, the quantitative analysis reveals that expansionary fiscal policy's costs outweigh its benefits. Thus, the policymaker sets government expenditures to zero, and the results are the same as optimal policies without recapitalization. Hence, this paper differs from the previous informal economy literature by showing that monetizing government expenditure is never optimal. Foreign currency debt increases inflation costs, and expansionary fiscal policy's benefits can not compensate for its costs.

I also construct a five-period event window to compare the model with the data. I simulate the model for 100,000 periods and discard 10,000 periods as burn-in, then identify

a crisis when the external credit falls below two standard deviations as in the macro-finance literature. I show the percent deviation from the trend of each variable in Figure 5.[10] The event window reveals that the model can closely capture the output and real exchange rate dynamics around a crisis.

4 Extensions

4.1 Capital Controls

Anticipated recapitalization discourages corporations from making private provisions for a crisis. In other words, they build up excessive leverage, eventually leading to a worse financial crisis. Thus, the policymaker can also tax foreign currency borrowing to limit corporations' exposure to currency risks. Quantitative results revealed that capital inflow taxes significantly decrease the frequency of crises. Portfolio share also significantly affects the rate of capital taxes.

4.2 Downward Nominal Wage Rigidity

Now, nominal wages can not decrease below a threshold despite adverse economic conditions. This extension leads to slow economic recovery as corporations struggle to adjust their cost structures in response to changing financial conditions. Understanding downward nominal wage rigidity is crucial for policymakers, as it can inform strategies to promote economic recovery.

4.3 UIP Deviation

I suppose that the UIP condition does not hold to show how different risk valuations affect the currency composition, as in Salomao and Varela (2021). Let suppose foreign currency financing becomes relatively cheaper. In that case, corporations raise foreign currency

[10] I detrend the variables using the Hodrick-Prescott filter.

investment financing.[11] Since foreign currency borrowing increases the exposure to currency risks, corporations take advantage of the UIP deviation so that the costs of facing currency risks do not exceed the benefits of cheap financing.

5 Conclusion

This paper studies optimal government interventions to recapitalize corporations under the informal economy. The policymaker finds it optimal to tax foreign lenders in addition to taxing households partly. This policy is desirable despite the effects of currency mismatch since an inflation tax lowers the tax burden on households and decreases the informal sector. However, anticipated dilution risks tilt corporations to increase foreign currency debt, permitting cheaper investment financing but raising exposure to currency risks. Besides, unlike previous informal economy literature, monetizing external debt to finance government expenditures is never optimal.

[11] These results are not reported but are available upon request.

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A Appendix

A.1 Figures

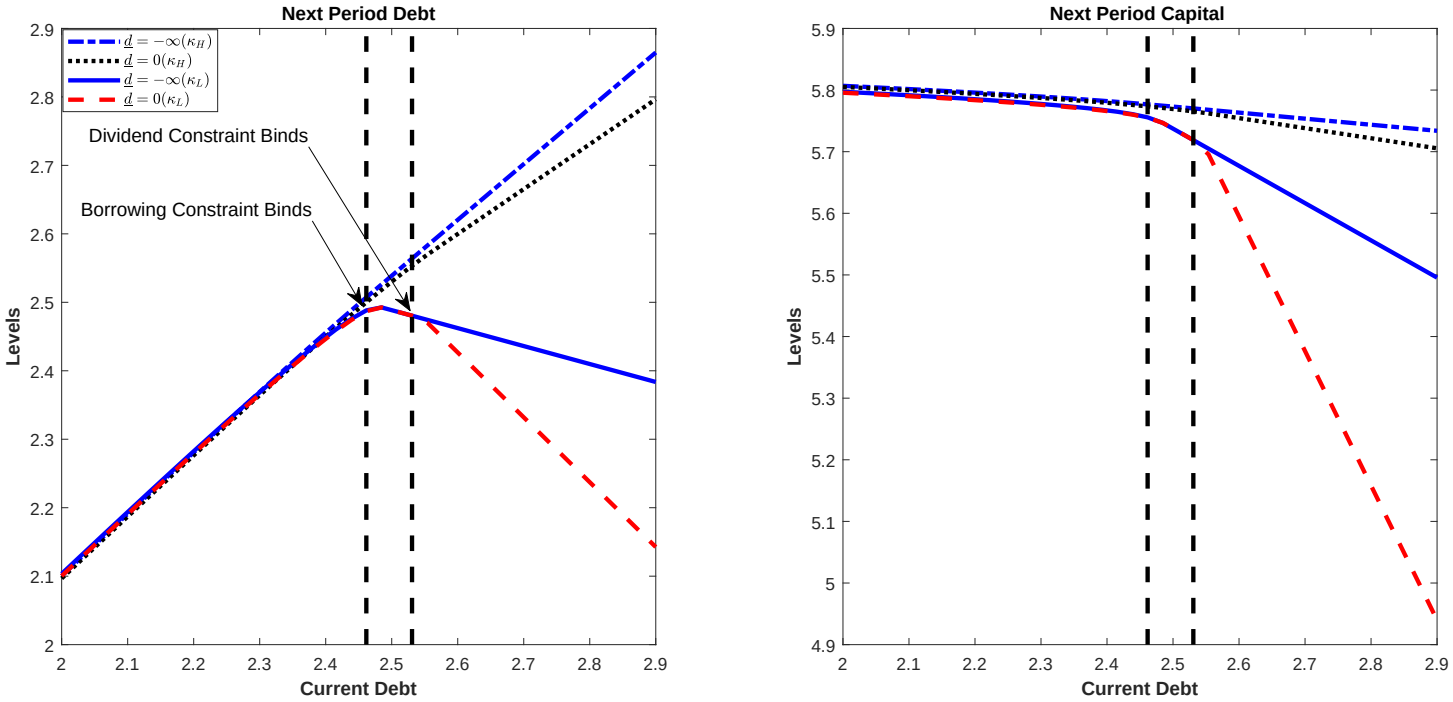


Figure 1: The dashed blue (black) line shows the policy functions without (with) domestic equity market constraints $\underline{d} = -\infty$ ($\underline{d} = 0$) in the high external borrowing regime κ_H. The solid blue and dashed red lines denote policy functions in the low borrowing regime κ_L with $\underline{d} = -\infty$ and $\underline{d} = 0$ respectively.

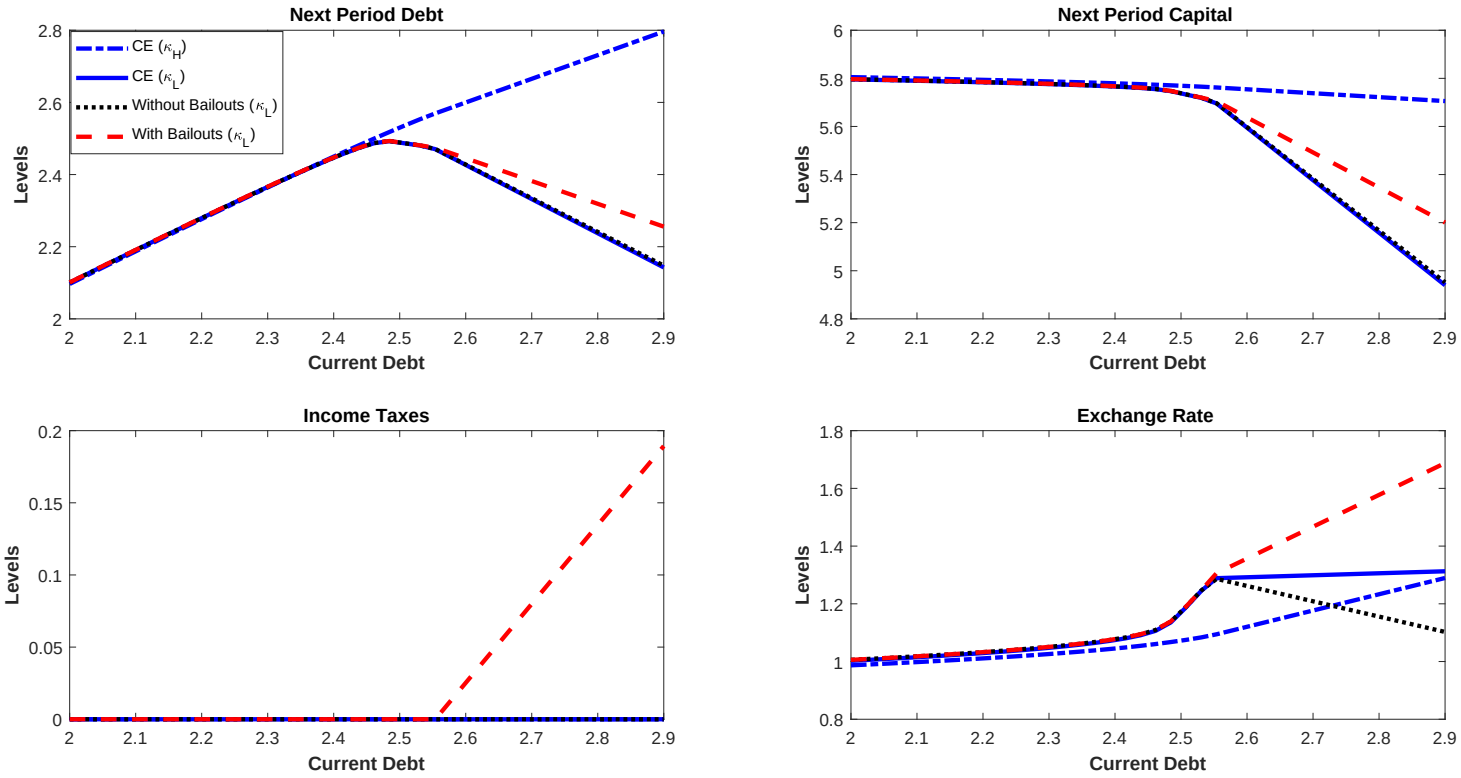


Figure 2: The dashed (solid) blue line shows the policy functions in the competitive equilibrium (CE) in the high (low) borrowing regime. Without (With) Bailouts refers to optimal policies without (with) interventions in the tight borrowing regime.

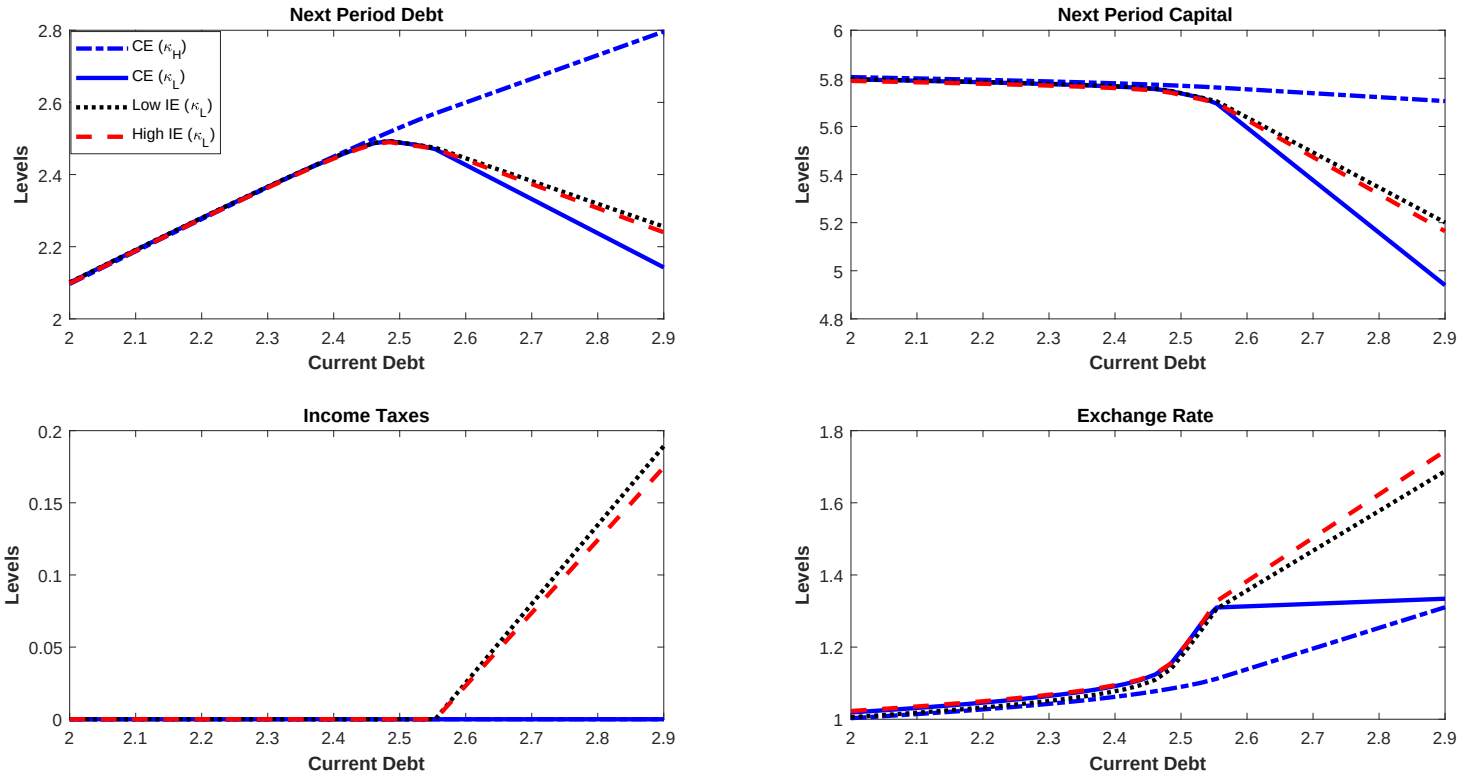


Figure 3: The dashed (solid) blue line shows the policy functions in the competitive equilibrium (CE) in the high (low) borrowing regime. Low (High) IE displays the policy functions under the presence of the low (high) share of the informal economy with the recapitalization program.

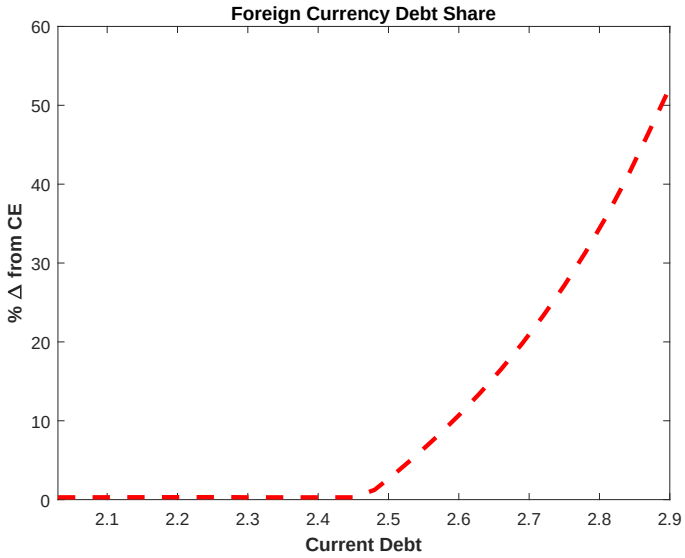


Figure 4: The figure shows the percent change in foreign currency debt share with recapitalization compared to the competitive equilibrium.

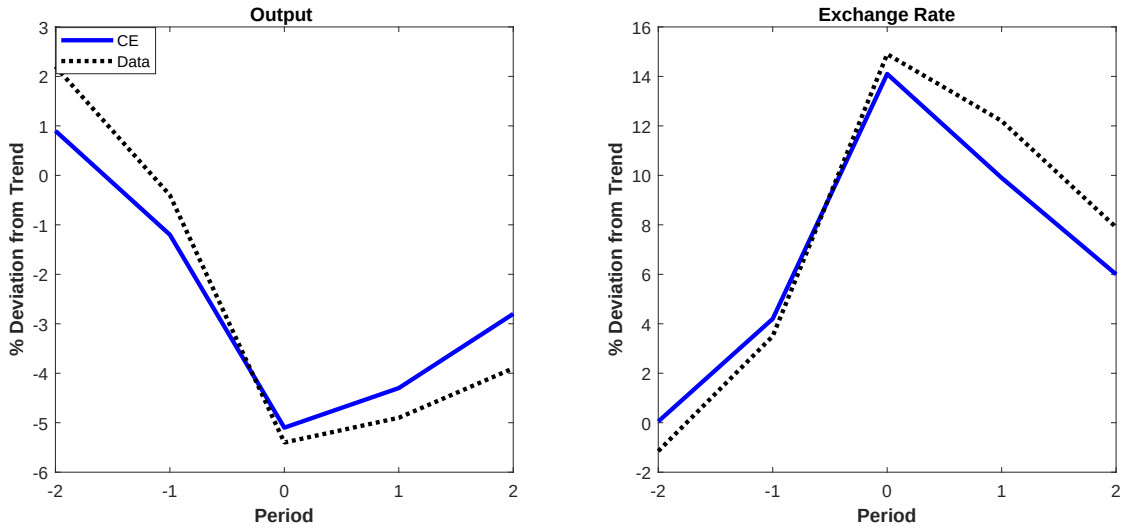


Figure 5: Event analysis compares the decentralized equilibrium (CE) with data.

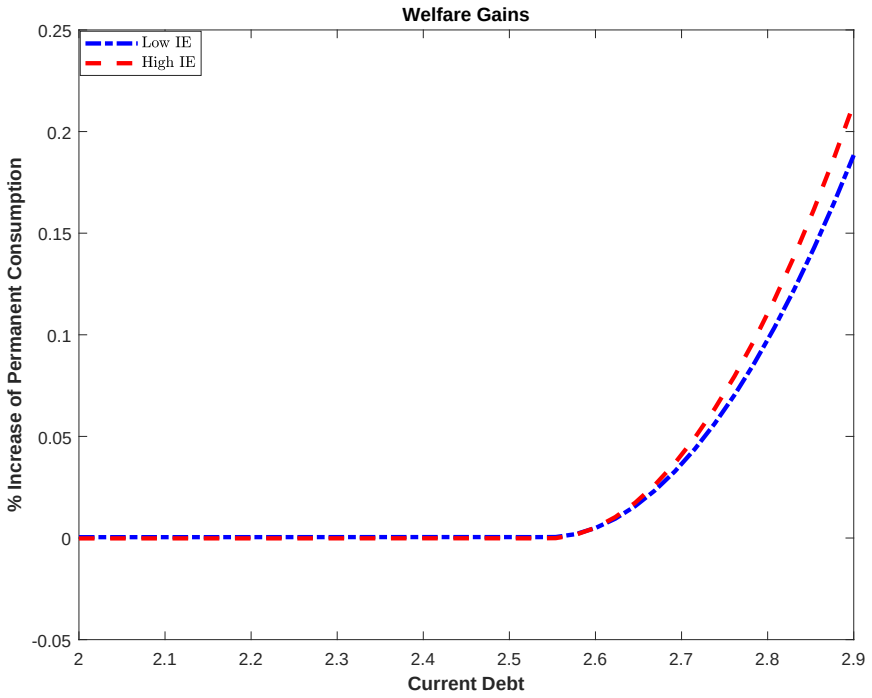


Figure 6: Low (High) IE displays the welfare gains under the presence of the low (high) share of the informal economy compared to the case without interventions.

A.2 Tables

Country	Average	Minimum	Median	Maximum
Argentina	24.14	20.80	24.41	27.18
Brazil	37.63	32.56	24.41	41.69
Colombia	33.31	25.25	34.95	39.10
India	23.91	17.89	24.84	27.83
Indonesia	24.11	21.05	24.29	25.90
Malaysia	31.49	26.07	31.10	35.04
Mexico	31.74	28.07	30.99	38.25
Peru	52.40	39.53	56.43	59.94
Philippines	39.31	28.04	41.39	45.40
Poland	25.10	16.67	26.14	30.21
Russia	38.42	31.04	37.68	48.73
Thailand	50.63	43.12	50.51	56.64
Turkey	31.38	27.33	32.03	34.51
Average	34.12	27.49	33.78	39.26

Table 1: The table shows the scale of the informal economy as a percent of GDP. The data are from Medina and Schneider (2018) over the period 1991 to 2015. Different approaches exist to measure the size of the informal economy, such as surveys, model-based estimations, electricity usage, the MIMIC approach, etc. I also reviewed other datasets estimated through these different methods and found that the size of the informal economy is similar for the countries listed in this table.

Parameter	Description	Value
σ	Risk Aversion	2.00
ν	Frisch Elasticity	1.00
β	Discount Factor	0.96
δ	Depreciation Rate	0.02
α_k	Capital Share	0.36
α_h^F	Formal Labor Share	0.64
α_h^I	Informal Labor Share	0.72
z^F	Formal Output Scale	0.12
z^I	Informal Output Scale	0.90
a	Share of Tradables	0.33
ξ	Elas. Subs. Btw. Tra. and Non-tra.	0.44
$\underline{d}$	Equity Threshold	0.00
a_p	Price Adjustment Cost	0.60
a_k	Capital Adjustment Cost	9.00
a_b	Portfolio Adjustment Cost	0.80
γ	Elasticity of Substitution	10.0
κ_H	High Financial Shock	0.55
κ_L	Low Financial Shock	0.43

Table 2: Parameter Values