Essays on Bailouts

Salim Ergene
Tekirdağ, Turkey

M.A. Economics, University of Virginia, 2016
M.A. Economics, Boğaziçi University, 2014
B.S. Teaching Mathematics, Boğaziçi University, 2012

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Department of Economics

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Abstract

In this dissertation, I study the optimal finance of bailouts that accelerate the recapitalization of the production sector in a crisis as well as the effects of anticipated bailouts on ex-ante risk-taking in the private sector.

Chapter - 1 studies the optimal way to finance bailouts, given the currency composition of external debt. Motivated by the recently growing domestic currency share of external government debt in the developing world, this chapter proposes that bailouts can be financed both through income taxes and through an inflation tax that reduces the real value of nominal liabilities to foreign lenders. The policymaker trades off the benefits and costs of the inflation tax. The cost includes distortionary effects on labor demand as well as the higher real external debt of the private sector as the exchange rate depreciates faster than prices rise. The quantitative analysis shows that the policymaker is more inclined to impose an inflation tax on international lenders than to collect income taxes from households to alleviate the undercapitalization of the production sector. Adding the inflation tax as a policy tool raises welfare gains significantly. Anticipated bailouts lead bank-firms to build-up higher leverage in pre-crisis that eventually gives rise to a worse contraction. Capital controls offset dilution risks and ex-ante moral hazard issues, thereby reducing the scale of bailouts in a crisis as well as the frequency of a crisis.

Chapter - 2 studies the optimal recapitalization of corporations in a financial crisis under the presence of the informal economy. The policymaker can finance the recapitalization through a combination of income taxes, but agents operating the informal production technology can evade income taxes at no cost, and an inflation tax on money holdings used for transactions. The quantitative analysis reveals that the growing size of the informal economy calls for a more considerable inflation tax to accelerate the recapitalization of corporations.

Despite the currency mismatch effects, this policy significantly raises welfare gains. Besides, capital inflow taxes are not optimal, and expansionary fiscal policies are not effective in recovering from a financial crisis under the presence of the informal economy.

Chapter - 3 studies the interaction between the effectiveness of bailouts in assuring ex-post financial stability and the currency composition of sovereign debt. In particular, the chapter studies how ex-ante risk-taking in the production sector affects the currency composition of government debt and vice-versa. The policymaker can hedge against adverse financial shocks by growing the share of debt in domestic currency and thereby can tax foreign lenders to bail out the production sector in a crisis. The quantitative analysis reveals that the production sector builds up higher leverage as the share of the domestic currency debt grows. Higher leverage leading to a more severe crisis eventually calls for a higher inflation tax to finance bailouts. International lenders anticipating debt dilution risks lend at a lower price, thereby the policymaker tilts the currency composition of debt to foreign currency as a response.

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All errors are my own.

Contents

Chapter 1

Time-Consistent Optimal Finance of Bailouts: Fiscal Policy versus Monetary Policy

1.1 Introduction

Banking crises are rare events coming along with long-lasting and deep recessions. A notable characteristic of emerging market banking crises is that they are accompanied by arbitrarily large-scale bailouts, the cost that taxpayers and international lenders finally bear.[1] In particular, Valencia and Laeven (2015) have documented that the average scale of bailouts accounts for 12% (30%) of GDP (financial assets) in the developing world, the scale ranging from 0.06% (0.3%) to 57% (135%), far from negligible.[2] I first ask whether governments should bail out insolvent banks and firms. If so, what is the optimal way to finance bailouts

[1] A bailout package typically consists of equity injections, financial asset purchases, and debt relief policies.
[2] Figure 1.20 shows the average scale of bailouts for some selected emerging market economies.

given the currency composition of external debt, including both private debt denominated in foreign currency (FC) and government debt denominated in domestic currency (DC)? This paper proposes that a policymaker can finance bailouts both through income taxes and through an inflation tax that reduces the real value of its nominal liabilities to foreign lenders.

The unprecedented scale of bailouts has recently sparked a heated policy debate. Supporters mainly argue that bailouts are necessary to mitigate bank-runs (Keister, 2016) and to recapitalize major insolvent banks and firms which would otherwise give rise to an extraordinarily sharp collapse in output due to prolonged credit crunch (Bianchi, 2016). However, opponents predominantly concern that anticipated bailouts create strong incentives to build-up excessive leverage ex-ante, thereby eventually leading to severe financial fragility (Farhi and Tirole, 2012). Thus, they propose ex-ante regulations to eliminate incentives to undertake interventions (Chari and Kehoe, 2016). In addition to moral hazard issues, bailouts can also undermine the fiscal capacity of a government that drives the risk premium of sovereign bonds as consistent with the classical empirical findings (Reinhart and Rogoff, 2011). The lower price of bonds may, in turn, feedback into the balance sheet of banks and firms that hold a significant amount of bonds in their portfolios.[3] The existence of this endogenous feedback loop eventually results in the co-occurrence of external twin crises, both banking and government debt crises (Acharya, Drechsler and Schnabl, 2014; Farhi and Tirole, 2017).

As emphasized by the related empirical and theoretical literature, fiscal policies are now unable to offer the desired level of bailouts. In other words, bailouts financed by only fiscal policies can not fully make sure the ex-post financial stability (Acharya, Drechsler and Schnabl, 2014; Farhi and Tirole, 2017; Reinhart and Rogoff, 2011). Consequently, the

[3] Becker and Ivashina (2017); Broner et al. (2014); Reinhart (2012); Reinhart and Sbrancia (2015) document the share of government bonds in the banks' portfolios.

classical monetary policy tool, such as an inflation tax, has become the central element of the ex-post financial stability toolkit to monetize bailouts. In line with this perspective, the paper examines the effectiveness of monetary policy to accelerate the recapitalization of the production sector, when it is no longer optimal to extract resources from taxpayers through income taxes. In particular, the paper proposes that the policymaker can finance bailouts by government debt dilution through DC depreciation, together with tax revenue. The recently growing DC share of government debt in the developing world constitutes a rationale for this proposal.[4]

Indeed, Du and Schreger (2016); Arslanalp and Tsuda (2014) document that the average DC share of the external government debt has approximately increased from 15% to 60% of external government debt for the 2003-2014 period in the emerging world.[5] However, the private sector still overwhelmingly accumulates massive FC external debt. In particular, the DC share of private external liabilities has only risen from 10% to 15% of external liabilities during the same period. The emphasis on the inability of fiscal policies to adequately stabilize an economy in response to a banking crisis appears to be also supported by the following empirical findings. Using data from a large sample of the developing countries, I find that more substantial private sector FC liability in pre-crisis is associated with more considerable depreciation and inflation in a crisis on the contrary to the predictions of the classical currency mismatch argument. This phenomenon, sometimes called "liability dollarization," dates back to Krugman (1999); Eichengreen, Hausmann and Panizza (2003) and related to the "fear of floating" concept revealed in Calvo and Reinhart (2002). The idea

[4] Figure 1.20 displays the share of DC debt as a percentage of the external government debt.

[5] While the average share before 2000 was relatively lower, not every country always suffered from the original sin (Eichengreen, Hausmann and Panizza, 2003). For instance, the Mexican government was able to accumulate sizeable DC denominated long-term debt before the Tequila crisis (Calvo and Mendoza, 1996). When the crisis hit, inflation increased from 7% to 35% in a year, and the exchange rate depreciated by about 90% in four months that were accompanied by massive bank bailouts. Russian and Turkish crises have the same pattern.

can be summarized as when the private sector is exposed to substantial FC external liability, whereas revenues are denominated in DC, a faster domestic currency depreciation than prices rise increases external liability burden. Under nominal frictions, the exchange rate depreciation hurts the balance sheet of the private sector. As a result, this literature predicts more conservative inflationary policies as the private sector is exposed to massive FC debt. However, these predictions are contradicted by the empirical findings in a systemic banking crisis window. More substantial depreciation and inflation with lower tax revenue in a crisis imply that governments in the emerging world may partly rely on inflation tax in urgent need of resources. By taking into account the recent trend in the DC share of government debt, the paper argues that it is essential to analyze the tendency to monetize bailouts along with its ex-ante effects on risk-taking and the price of nominal government liabilities as well as its ex-post implications for financial stability.

Motivated by the above-mentioned stylized facts related to the emerging world, I develop a dynamic stochastic general equilibrium model to study the optimal time-consistent finance of bailouts under nominal and financial frictions. A continuum of bank-firms[6] that operates a production technology in the non-tradable sector under monopolistic competition[7] suffers from the currency mismatch between DC revenues and FC external liabilities as well as faces price adjustment costs. Households are the shareholders of bank-firms. Binding external borrowing and domestic equity market constraints prevent bank-firms from financing the desired level of investment. In particular, domestic financial frictions result in a sharper fall

[6]Bank-firms refer to the integration of banks and firms. This assumption may reflect the view that resources can be transferred between banks and firms without frictions or banks operate a production technology. Alternatively, banks and firms could be modeled separately. In that case, banks could borrow from abroad in FC and invest in physical capital. Then, they could rent capital to firms and receive capital returns. Modeling banks and firms separately would not change the main predictions of the model as there is no friction in the loan market. This assumption also reflects that frictions in the deposit market have minor effects compared to the frictions in the external credit market.

[7]There is no flow of funds between the tradable and non-tradable sectors. Thus, the only reason for introducing the non-tradable sector is to generate a currency mismatch between revenues and liabilities.

in investment in the tight credit regime, since bank-firms otherwise would fund the investment opportunities by promoting new equity from households when the external borrowing constraint binds. Households are not willing to transfer funds to the production sector in the tight credit regime since they do not recognize that future benefits outweigh contemporaneous costs. However, a policymaker can extract resources from households and international lenders to accelerate the recapitalization of bank-firms.

The normative analysis characterizes that bank-firms under invest in the competitive equilibrium since they fail to internalize how labor demand affects prices, including the relative price of non-tradable goods and wages, and that in turn influence the tightness of the domestic financial constraint. However, the social planner recognizes these inefficiencies. Thus, the planner reduces labor demand to lower wages and increase the relative price to relax the domestic dividend constraint. When lump-sum taxes are available to alleviate the under-capitalization in the production sector, the competitive equilibrium allocations coincide with the social planner allocations. However, I take the perspective that lump-taxes are infeasible and focus on the time-consistent finance of bailouts through distortionary policy tools. The Ramsey problem also suffers from time inconsistency. The policymaker may promise not to undertake bailouts to mitigate moral hazard issues, but after an adverse financial shock, the policymaker finds it optimal to bail out the production sector. Therefore, this promise is not credible in this framework.

Time-consistent optimal policies are solved with value function iteration, and the competitive equilibrium allocations are obtained with the Euler equation method based on policy function iteration. To approximate policy functions and value functions outside the grid points, I use B-splines interpolation methods, and calibrate the model for an average of a large sample of the developing world economies and compare the model dynamics with the experience of banking crisis episodes of an average economy. In the quantitative analysis, I first suppose that the benevolent domestic policymaker has a restricted menu of policy tools. The policymaker can only impose income taxes on households to finance its expenditures. I then extend the model by introducing long-term government debt denominated in DC. The purpose of expanding the menu of policy tools step by step is to study the relative effectiveness of each policy. I quantitatively compare the competitive equilibrium allocations with the allocations of optimal policies to show how much each policy accelerates capital accumulation in the production sector.

Accordingly, I first consider the case where the policymaker can only impose income taxes on households to finance bailouts and government expenditure. Distortionary taxation discourages households from increasing labor supply, thereby preventing wages from decreasing in favor of bank-firms. As a result, the benefits of bailouts are limited. Unlike the Ramsey planner, the policymaker under discretion can not credibly promise higher dividend and wage payments in the future as compensation of lower-wage and dividend payments in the current period. Thus, time-consistent policies less incentivize labor supply.

Besides, I solve the model with a fixed income tax rate. Tax revenues are transferred to the bank-firms' balance sheets. I find that the policymaker further reduces employment when both constraints bind. Thus, optimal policies are effective in decreasing wages in favor of bank-firms. They further accelerate the recapitalization in the production sector. Bailouts financed by fixed tax rates raise welfare only at high debt levels, whereas they reduce welfare at modest debt levels.

The policymaker also finds it optimal to increase government spending when both constraints bind, since this policy raises the relative price of non-tradable goods, thereby relaxing the domestic financial constraint. I suppose that the policymaker chooses aggregate spending, then it is allocated to non-tradable goods in fixed proportion to moderate computational costs. I find that bailouts allow for a quicker recovery from a contraction since the price support policy is less effective in reducing wages, even though it leads to a higher relative price of non-tradable goods. In particular, increasing government expenditure in a crisis results in a smaller rise in output.

These exercises show that bailouts and government expenditure financed through only fiscal policies are unable to maintain financial stability fully. In particular, they can not eliminate the domestic equity market frictions. I then ask whether monetary policy is effective in financing bailouts and government expenditure when it is no longer optimal to extract resources from households through fiscal policies. To address this question, I then extend the basic setup by introducing long-term government debt denominated in DC and held by risk-neutral international lenders. This extension gives rise to perverse incentives to impose an inflation tax on foreign lenders. The policymaker can now finance bailouts both through income taxes and through an inflation tax that reduces the real value of its nominal liabilities to foreign lenders. The policymaker trades off the benefits and costs of the inflation tax. The cost includes distortionary effects on labor demand as well as the higher real external debt of the private sector as the exchange rate depreciates faster than prices rise. To show how bailouts affect the incentives to allow for more substantial inflation, I first analyze the model without bailouts.

When the policymaker is not allowed to offer bailouts, fear of floating is present. The policymaker follows a relatively more conservative inflation policy in a crisis. In that case, the policymaker trades off the lower debt burden and the lower price of the government debt as extensively studied by the recent sovereign debt literature (Du and Schreger, 2016; Engel and Park, 2017; Ottonello and Perez, forthcoming). Besides, inflationary policies affect the tightness of domestic financial frictions indirectly. Lower debt burden allows for lower income taxes and higher labor supply. Thus, they facilitate the transfer of resources from wage payments to capital accumulation. However, the costs of inflation prevent the policymaker from further relying on this policy in a crisis. I find that the policymaker lowers inflation, thereby raising the price of nominal debt in a crisis.

I show that the incentives to reduce the real value of nominal debt are quite different when the policymaker is permitted to carry out bailouts. The policymaker can now transfer resources from international lenders to the production sector through an inflation tax. Bailouts can be partly financed through an inflation tax since it is very costly to raise income taxes when the marginal utility of consumption is very high. The quantitative analysis shows that the policymaker is more inclined to impose an inflation tax on international lenders than to collect income taxes from households to alleviate the under-capitalization of the production sector. Adding the inflation tax as a policy tool raises welfare gains. Therefore, the paper proposes that fiscal policy should be supplanted by monetary policy to finance bailouts.

Anticipated bailouts, on the one hand, lead bank-firms to build-up higher leverage in pre-crisis that eventually gives rise to a worse contraction. In other words, they discourage bank-firms to private provision for a recession, thereby resulting in higher debt, more considerable depreciation, and inflation in a crisis. On the other hand, they reduce the price of the nominal government debt since rational lenders recognize the incentives to reduce the real value of nominal debt when the hit chance of a future adverse financial shock is very high. They ask for higher returns or lend at a lower price. Then, I also ask how a bailout package should be designed to mitigate ex-ante issues. Bailouts should be implemented in a systemic crisis rather than targeting one big bank-firm. Besides, they should be supplanted by prudential policies to alleviate ex-ante risk.

The paper also provides an integrated analysis of capital controls, fiscal policy, monetary policy, and bailouts. In the aftermath of the global financial crisis, old-fashioned capital controls have been proposed to reduce capital flow volatility. They restrict external borrowing that calls for a smaller scale intervention during crisis times. They also mitigate expected dilution risks, thereby increasing the price of nominal securities. Within this construction, I show that capital controls are useful to discipline dilution risks. In general, capital controls advised in the literature to alleviate the adverse effects of sharp capital flow reversal. Therefore, revealing the motivation of the policymaker to discipline its future-self by capital controls is a novel contribution of this paper.

Taken together, the model captures the crisis dynamics of standard variables. Besides, it captures the realistic scale of bailouts in a crisis. It is crucial to get these features to analyze the circumstances in which a crisis occurs. It is also critical to examine which policies are effective in mitigating the collapse of investment in the production sector.

Relation to the Literature. This paper relates to several strands of the macro-finance literature. First, it builds on the literature related to the credit channel and the financial accelerator mechanism.[8] Gertler and Karadi (2011), among many others, contribute that temporary shocks to asset returns, on the one hand, distort the net worth accumulation of financial intermediaries that are accompanied by deep recessions. On the other hand, relatively small shocks lead to amplification effects through asset prices. Especially, declining net worth results in a drop in asset prices that further reducing the net worth of leveraged banks. Other than this amplification mechanism, Gertler and Karadi (2011) also provide that a central bank's asset purchase moderates the contraction in output. This literature supposing constraints are always binding focuses on log-linear dynamics around a deterministic steady-state and explore the roles of ad hoc policy rules. However, I study optimal time-consistent policies by addressing non-linear dynamics beyond a deterministic steady state as in Bianchi and Mendoza (2018); Devereux, Young and Yu (forthcoming).

Second, Perez (2015); Sosa-Padilla (forthcoming); Balke (2016) study the negative feed-

[8] The well-known classical examples of these approaches are Bernanke and Gertler (1989); Kiyotaki and Moore (1997); Carlstrom and Fuerst (1997); Bernanke, Gertler and Gilchrist (1999).

back loop between the government and banks. They indicate that the sovereign default results in adverse balance sheet effects, thereby undermining banks' ability to finance investment. By estimating a non-linear version of the Gertler and Karadi (2011) model, Bocola (2016) reports that anticipated sovereign default risk slows down the net worth accumulation in the financial sector. Mendoza and Yue (2012) contribute that the sovereign default leads to an efficiency loss in the production sector as imported inputs are substituted by less efficient domestic intermediate counterparts. Unlike these papers, my model incorporates government debt denominated in DC. Accordingly, the paper explores the negative feedback loop between bank-firms and the government through not only the fiscal policy but also the monetary policy. In particular, a massive FC liability in a contraction calls for more substantial scale bailouts, thereby affecting the inflation choice. An inflation tax on foreign lenders, in turn, creates adverse balance sheet effects due to the currency mismatch between DC revenues and FC debt.

In recent work, Du and Schreger (2016) develop a model to investigate incentives to dilute real government debt repayment. Ottonello and Perez (forthcoming) study the currency composition of external government debt under an ad hoc inflation cost function. They also provide empirical evidence that the share of DC government debt is pro-cyclical. They argue that the government foregoes hedging benefits of DC debt to avoid inflationary costs. Engel and Park (2017) solve an optimal contract problem that characterizes state-contingent returns in DC under default as well as dilution risks. These papers study the factors that drive the currency composition of sovereign debt. My work differs from this literature by exploring the incentives to monetize bailouts, given the currency composition of external debt. The paper also accounts for the effects of an inflation tax to monetize bailouts on the FC liability burden. Despite many studies on the fiscal channel for spillover of sovereign default risk, little research has been carried on the spillover of dilution risk.

The paper also relates to the theoretical literature that studies trade-offs between ex-ante moral hazard effects of bailouts and their ex-post implications on financial stability. In particular, Farhi and Tirole (2012) recommend ex-ante regulations to rule ex-post bailouts out as they deepen financial fragility. However, Keister (2016) provides that commitment to no-bailout policy accelerates bank-runs and argues that bailouts are ex-ante efficient. Chari and Kehoe (2016) propose that it is optimal to bail out firms to avoid bankruptcy costs, even if the competitive equilibrium is efficient. Gertler, Kiyotaki and Queralto (2012) examine the moral hazard effects of a credit policy under debt and equity financing around a risk-adjusted steady state. Bianchi (2016); Jiao (2018) contribute that domestic equity frictions, together with external borrowing constraints, generate scope for government interventions since the production sector can not finance the desired level of investment in the tight credit regime. However, these papers are silent about the fiscal capacity of a government to finance interventions. Given that the DC share of external government debt has become sizable in the emerging world, it has been more vital to examine the effects of dilution risks for financial stability. Unlike Jiao (2018), I also show the relative effectiveness of expansionary fiscal policies and the effectiveness of capital inflow taxes in mitigating the ex-ante build-up of excessive leverage.

Finally, the paper also builds upon the classical monetary policy literature with financial constraints.[9] Ottonello (2015); Schmitt-Grohe and Uribe (2016); Na et. al. (2018) study optimal devaluation under nominal rigidities. The paper differs from these recent seminal works by introducing bailouts and DC debt. The recent literature proposes that monetary policy should be supplanted by capital controls to mitigate the effects of volatile capital flows. In particular, Bianchi and Mendoza (2018); Devereux, Young and Yu (forthcoming) quantify

[9]The classical examples among many others are Rotemberg and Woodford (1999); Woodford (2002); Clarida, Gali and Gertler (2001). Gali and Monacelli (2005) extend the classic approaches with an exchange rate policy.

the ex-ante and ex-post effects of optimal time-consistent capital controls. Devereux, Young and Yu (forthcoming) find that capital controls are welfare reducing and not optimal outside of a crisis. However, Bianchi and Mendoza (2018) support these policies to sustain collateral value based on the current asset prices. In particular, they show that it is optimal to restrict capital inflows to prop up current asset prices at the onset of a crisis. I also find that capital controls are desirable for several reasons. First, they moderate expected dilution risks, thereby raising the price of DC debt. Second, since anticipated bailouts create incentives to build up ex-ante risk, which eventually calls for more substantial scale bailouts, the policymaker finds it optimal to restrict ex-ante FC borrowing to discipline the inflationary policies of its future-self.

Layout. Section 1.2 introduces the model economy. Section 1.3 characterizes inefficiencies in the competitive equilibrium that justify a scope for government interventions. Section 1.4 describes time-consistent optimal policies. Section 1.5 explains solution methods, calibration strategies, and shows the main results. Section 1.6 introduces some extensions such as inflation-linked debt, financial repression, and risk-averse pricing of nominal debt. Section 1.7 shows welfare gains corresponding to each policy. Section 1.8 illustrates the empirical findings. Section 1.9 concludes.

1.2 Model

I develop a dynamic stochastic general equilibrium small open economy model. Time is discrete and the horizon is infinite. The model environment is populated by infinitely lived households, bank-firms, international lenders, and a benevolent domestic policymaker. Households consume tradable and non-tradable goods and supply labor and are also bank-firms' shareholders. Bank-firms operate in the non-tradable sector,[10] issue FC external bonds, invest in physical capital, import intermediates, and have access to production technology. The interest rate of FC bonds is exogenous to the small open economy. The policymaker issues bonds denominated in DC. They are held by risk-neutral foreign lenders. The policymaker also chooses government expenditure, inflation to reduce the burden of its outstanding liabilities to foreign lenders, collects income taxes from households, may bailout bank-firms, and carry out macro-prudential policies to mitigate the moral hazard issues of bailouts.

1.2.1 Households

There is a continuum of identical households of unity mass. They have lifetime preferences given by:

$$\max_{c_t^T, c_t^N, h_t} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} \tag{1.2.1}$$

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 of labor supply. h_t is the 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. The utility function is in the form of GHH (Greenwood, Hercowitz, and Huffman, 1988) as widely used in the macro-finance literature that eliminates the wealth effect on labor supply. Otherwise,

[10]This is a reasonable assumption given the fact that the share of the non-tradable sector is sizable in the developing world. A significant fraction of banks and firms operate in this sector.

these models would fail to produce realistic employment dynamics in crisis times.[11]

Each period households receive tradable endowments y_t^T that follow a finite-state, stationary Markov process.[12] They are the equity owners of bank-firms and do not have access to bond markets, but receive dividend payments d_t from the production sector. The representative agent's budget constraint in nominal terms is

$$P_t^T c_t^T + P_t^N c_t^N = P_t^T y_t^T + W_t h_t + P_t^T d_t$$

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

$$P_t^T = P_t^{T*} e_t = e_t$$

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

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

Then, the budget constraint in terms of the price of tradable goods is

$$c_t^T + p_t^N c_t^N = y_t^T + w_t h_t + d_t \tag{1.2.2}$$

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.

Then, the intratemporal consumption Euler gives the relative price as a function of consumption allocations:

$$p_t^N = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{\frac{1}{\xi}} \tag{1.2.3}$$

[11] While in this set up sectoral consumption allocations affect the labor supply through the relative price of non-tradable goods, I find that the GHH form is still essential to produce empirically relevant employment dynamics.

[12] I suppose that tradable endowments have two states, such as high and low states, $y_t \in \{y_h, y_l\}$.

1.2.2 Production/Non-Tradable Sector

The non-tradable sector consists of competitive final goods producers and a continuum of monopolistically competitive intermediate bank-firms.

Final Goods Producers

The intermediate goods y_{jt}^Ns are aggregated by the Dixit-Stiglitz technology:

$$y_t^N = \left[\int_0^1 \left(y_{jt}^N \right)^{\frac{\gamma-1}{\gamma}} dj \right]^{\frac{\gamma}{\gamma-1}}$$

where $\gamma > 1$ captures the elasticity of substitution among different varieties of non-tradable goods. The price index in the non-tradable sector is

$$P_t^N = \left[\int_0^1 \left(P_{jt}^N \right)^{1-\gamma} dj \right]^{\frac{1}{1-\gamma}}$$

where P_{jt}^N is the price of a variety j.

Cost minimization implies that the optimal demand for each variety j is

$$y_{jt}^N = \left(\frac{P_{jt}^N}{P_t^N} \right)^{-\gamma} y_t^N$$

Intermediate Goods Producers/Bank-Firms

A continuum of bank-firms indexed by $j \in [0, 1]$ hires physical capital k_{jt} and domestic labor h_{jt}, and imports intermediate inputs v_{jt} in order to produce a variety j in a monopolistic competitive environment:

$$y_{jt}^N = z k_{jt}^{\alpha_k} v_{jt}^{\alpha_v} h_{jt}^{\alpha_h} \tag{1.2.4}$$

with $\alpha_k + \alpha_v + \alpha_h \leq 1$, $\alpha_k, \alpha_v, \alpha_h \geq 0$ and they denote the share of capital, imports, and labor, respectively. z is a scale parameter of a variety j.

Each bank-firm j starts the period with external debt b_{jt} in FC and capital k_{jt}, then borrows b_{jt+1} at an exogenous interest rate r_t from abroad,[13] invests in the capital i_{jt}, hires labor h_{jt}, imports intermediate inputs v_{jt}, makes dividend payments d_{jt} to households, and can reset the DC price of a variety j P^N_{jt} each period. The price adjustment problem is subject to the quadratic cost as in 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 in the non-tradable sector, and a_p is the price adjustment cost parameter. This adjustment cost plays a vital role in the model by generating price stickiness, currency mismatch, and inefficient wedge for labor demand.

Thus, the flow budget constraint of each bank-firm j in terms of tradable goods is

$$d_{jt}+b_{jt}+i_{jt} = (1+\tau_y)\frac{P^N_{jt}}{P^T_t}y^N_{jt} - w_t h_{jt} - p_v v_{jt} + \frac{b_{jt+1}}{1+r_t} - \frac{a_p}{2}\left(\frac{P^N_{jt}}{P^N_{jt-1}} - \pi^N\right)^2 - \tau_y p^N_t y^N_t \quad (1.2.5)$$

where p_v is the price of intermediate inputs in terms of tradable goods, and it is exogenous to the small open economy. There is an output subsidy $\tau_y = \frac{1}{\gamma-1}$ that corrects the monopolistic distortion and is funded by lump-sum taxes on all bank-firms.[14] The proportional output subsidy resolves the inefficiency due to the monopolistic competition as in Rotemberg and Woodford (1999).

The capital accumulation is also 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 scale parameter. While the capital adjustment cost is not crucial to produce

[13] The interest rate follows a Markov process with two states, such as high and low states $r_t \in \{r_h, r_l\}$. I also analyze the model dynamics when the interest rate is positively correlated with the sovereign bond spread. The results still carry through.

[14] Alternatively, the production subsidy could also be financed by distortionary taxation. That would not change the main results of the paper.

fundamental model dynamics, it significantly improves the quantitative performance of the model by generating investment volatility similar to its counterpart in the data. Also, it increases the real costs of disinvestment in a crisis. Then, capital accumulation technology is

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

where δ denotes the depreciation rate.

Besides issuing intertemporal bonds, bank-firms borrow intratemporal loans at a zero interest rate to finance a constant fraction of imported intermediate inputs in advance. However, total debt, including both intertemporal and intratemporal debt, limited not to exceed the stochastic fraction κ_t of investment.[15] The collateral constraint is[16]

$$\frac{b_{jt+1}}{1+r_t} + \theta p_v v_{jt} \leq \kappa_t k_{jt+1} \tag{1.2.6}$$

where θ denotes the fraction of imported inputs financed in advance. The working capital loan assumption is consistent with the empirical evidence which documents that about 40% of such loans are secured with collateral.[17] Furthermore, limited access to working capital loans slows down economic activity during a contraction. A binding borrowing constraint increases the effective factor costs, thereby reducing the production. That puts downward pressure on current dividend payments and affects the expected streams. The presence of the intratemporal loans in the borrowing constraint worsens the slump in investment.

It is important to note here that a model with constant financial shock can also produce

[15]The financial shock has two states: $\kappa_t \in \{\kappa_h, \kappa_l\}$.

[16]As in Bianchi and Mendoza (2018), the production sector borrows working capital loans to finance some fraction of imported intermediate goods in advance. An alternative working capital constraint that imposes the finance of some fraction of wage bill or capital rent in advance would also work similarly. However, such a type of working capital constraint generates an empirically more relevant import-to-GDP ratio.

[17]See The Federal Reserves 2013 Survey of Terms of Business Lending report and Bianchi and Mendoza (2018).

realistic crisis dynamics. However, the stochastic financial shock improves the model's quantitative performance by producing a leverage ratio in pre-crisis and a correlation between capital flows and business cycles that are both consistent with empirical estimates (Mendoza, 2010; Jermann and Quadrini, 2012; Bianchi, 2016).

As observed in many countries during the global financial crisis, tight borrowing periods were accompanied by low-interest rates. However, there is no endogenous feedback mechanism in the model to generate a positive comovement between financial shocks and interest rates. Thus, I suppose that there is a positive correlation between financial shock and the world interest rate in line with the related literature in numerical analysis (Mendoza, 2010; Bianchi and Mendoza, 2018).

Bank-firms' capacity to finance investment is also limited by domestic equity market frictions that play very crucial roles to produce crisis episodes with realistic quantitative features:

$$\underline{d} \leq d_{jt} \tag{1.2.7}$$

here $\underline{d}$ measures the degree of equity market frictions. I impose a widespread limited liability constraint $\underline{d} = 0$ in numerical exercises. The quantitative analysis illustrates that the borrowing constraint first binds, then it puts pressure on the balance sheet to cut down dividend payments for a given level of investment. However, domestic financial frictions impede bank-firms to reduce dividend payments to households beyond $\underline{d}$ when the external borrowing binds. In other words, a tight dividend constraint prevents bank-firms from financing the desired level of investment by raising new equity from households. Consequently, the presence of this constraint gives rise to a persistent collapse in investment during a contraction.

Due to the above-mentioned model features, resources are more valuable within bank-firms in the tight credit regime. However, households are not willing to transfer funds to the production sector at those times, since they can not recognize that future benefits outweigh contemporaneous costs. On the contrary, the policymaker may facilitate the flow of funds from households to bank-firms' balance sheets to recapitalize the production sector. Hence, this constraint plays a vital role in the model to generate scope for interventions. Absent equity market frictions, bank-firms would fund investment by raising new equity from households when the external borrowing is limited. Thus, bailouts would be ineffective. More substantial FC debt, together with the tight domestic equity constraint, calls for more substantial scale bailouts.

I focus on the symmetric recursive equilibrium, thus drop index j. Let $s_t \equiv \{y_t^T, r_t, \kappa_t\}$ show the exogenous states, B_t and K_t the economy's aggregate bond and capital positions, respectively. Thus, the state variables of a bank-firm are the individual states $\{b_t, k_t\}$ and the aggregate states $S \equiv \{s_t, B_t, K_t\}$. Bank-firms maximize the shareholders' value. They discount the future by households' stochastic discount factor.

$$m(S_t, S_{t+1}) = \frac{\beta \left(c_{t+1} - \chi \frac{h_{t+1}^{1+\nu}}{1+\nu}\right)^{-\sigma} \left[a \left(c_{t+1}^T\right)^{1-\frac{1}{\xi}} + (1-a)\left(c_{t+1}^N\right)^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}-1} a \left(c_{t+1}^T\right)^{-\frac{1}{\xi}}}{\left(c_t - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{-\sigma} \left[a \left(c_t^T\right)^{1-\frac{1}{\xi}} + (1-a)\left(c_t^N\right)^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}-1} a \left(c_t^T\right)^{-\frac{1}{\xi}}}$$

Let W denote the dividend market value of a bank-firm. Then, the optimization problem in recursive form is

Definition 1.1 (**The Recursive Problem of Bank-Firms**). *The representative bank-firm chooses allocations to maximize the shareholder value given prices and the output subsidy:*

$$W\left(k_t, b_t, S_t\right) = \max_{\Gamma_t} \left\{d_t + \mathbb{E} m\left(S_t, S_{t+1}\right) W\left(k_{t+1}, b_{t+1}, S_{t+1}\right)\right\}$$

where $\Gamma_t \equiv \{d_t, h_t, v_t, k_{t+1}, b_{t+1}\}$ *and subject to*

1. *the budget constraint*

$$d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + \frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2$$

2. *and the collateral constraint*

$$\frac{b_{t+1}}{1+r_t} + \theta p_v v_t \leq \kappa_t k_{t+1}$$

3. *and the dividend constraint*

$$\underline{d} \leq d_t$$

1.2.3 Competitive Equilibrium

Since the exogenous shocks follow finite-state, stationary Markov process, I focus on the recursive stationary competitive equilibrium. Implicit in the household's budget constraint is that the total number of shares is normalized to unity. It implies that bank-firms can not raise new shares from households. Then, combining the household's budget constraint with the bank-firm's budget constraint gives rise to the aggregate resource constraint for tradable goods:

$$c_t^T + b_t + k_{t+1} = y_t^T + \frac{b_{t+1}}{1+r_t} + (1-\delta)k_t - p_v v_t - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 \quad (1.2.8)$$

Non-tradable goods are only consumed domestically. The resource constraint is

$$y_t^N = c_t^N \quad (1.2.9)$$

I suppose that the policymaker stabilizes inflation in the non-tradable sector in the competitive equilibrium solution to show the relative effects of inflationary policies in the following sections.[18]

[18] Inflation could also be a function of the deviation of the non-tradable output from its steady-state level.

Definition 1.2 (The Recursive Competitive Equilibrium). *Given the exogenous state vector* $s_t \equiv \{y_t^T, r_t, \kappa_t\}$*, the aggregate state vector* $S_t \equiv \{s_t, B_t, K_t\}$*, the government policies* $\Omega(S_t)$ *and the output subsidy* τ_y*, the recursive stationary competitive equilibrium consists of the equity value* $W(k_t, b_t, S_t)$*, the stochastic discount factor* $m(S_t, S_{t+1})$*, policy functions for households* $\hat{c}(S_t; \Omega(S_t))$*,* $\hat{c}^T(S_t; \Omega(S_t))$*,* $\hat{c}^N(S_t; \Omega(S_t))$*,* $\hat{h}(S_t; \Omega(S_t))$*, policy functions for bank-firms* $\hat{d}(S_t; \Omega(S_t))$*,* $\hat{h}(S_t; \Omega(S_t))$*,* $\hat{v}(S_t; \Omega(S_t))$*,* $\hat{b}'(S_t; \Omega(S_t))$*,* $\hat{k}'(S_t; \Omega(S_t))$*, prices* $\hat{p}^N(S_t; \Omega(S_t))$*,* $\hat{w}(S_t; \Omega(S_t))$*,* $\hat{\eta}(S_t; \Omega(S_t))$*,* $\hat{\mu}(S_t; \Omega(S_t))$*,* $\hat{\pi}^N(S_t; \Omega(S_t))$ *and the law of motion of the aggregate variables* $S_{t+1} = \Lambda(S_t)$ *such that*

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

2. *Policy functions* $\hat{d}(S_t; \Omega(S_t))$*,* $\hat{h}(S_t; \Omega(S_t))$*,* $\hat{v}(S_t; \Omega(S_t))$*,* $\hat{b}'(S_t; \Omega(S_t))$*,* $\hat{k}'(S_t; \Omega(S_t))$*,* $\hat{\pi}^N(S_t; \Omega(S_t))$ *solve the bank-firm's recursive problem given prices and government policies and the output subsidy* τ_y*.*

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 the collateral and dividend constraints, respectively. The resource constraints Equation 1.2.8 and Equation 1.2.9 both hold.*

4. *The law of motions are consistent with individual states:*

$$\hat{K}'(S_t; \Omega(S_t)) = \hat{k}'(S_t; \Omega(S_t)) \quad \textit{and} \quad \hat{B}'(S_t; \Omega(S_t)) = \hat{b}'(S_t; \Omega(S_t))$$

and the stochastic processes for y_t^T, r_t, κ_t*.*

5. *The representative household's marginal rate of substitution gives the stochastic discount factor for the bank-firm's problem.*

This extension would not affect the role of the domestic equity market friction and fundamental model predictions.

Given that $\beta(1+r) < 1$ under usual parametrization, the collateral constraint binds in the deterministic steady state. For the standard values of the depreciation rate and capital share, the capital return is sufficiently high to fund investment opportunities in the deterministic steady state. In other words, the dividend constraint is always slack around the deterministic steady-state. However, beyond the deterministic steady state, bank-firms accumulate precautionary savings against the risk of sharp consumption drop. Thus, constraints bind occasionally. Thereby the model needs to be solved by global methods.

1.3 Constrained Efficiency

Before investigating optimal time-consistent policies, I first highlight the inefficiency in the decentralized equilibrium. The social planner maximizes the representative household's lifetime utility subject to the resource constraints and the implementability constraints given by the optimality conditions of the private sector. I follow Bianchi (2016); Bianchi and Mendoza (2018) and suppose that the planner's problem is also constrained by the relative price of non-tradable goods and wages given in the competitive equilibrium.[19] In other words, goods and labor markets clear competitively. As proved in the online Appendix of this paper, the competitive equilibrium implementability constraints are slack, and the constrained efficient allocations can be reduced to the following problem:

Definition 1.3 (**Constrained Efficiency**). *The planner chooses allocations to maximize the lifetime social utility of the representative household:*

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

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

[19] Kehoe and Levine (1993) defines this formulation as constrained efficiency.

1. *the tradable resource constraint*

$$b_t + c_t^T + k_{t+1} = y_t^T + \frac{b_{t+1}}{1+r_t} + (1-\delta)k_t - p_v v_t - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2$$

2. *and the non-tradable resource constraint*

$$c_t^N = y_t^N$$

3. *and the collateral constraint*

$$\frac{b_{t+1}}{1+r_t} + \theta p_v v_t \leq \kappa_t k_{t+1}$$

4. *and the dividend constraint*

$$\underline{d} \leq p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta)k_t - k_{t+1} - b_t + \frac{b_{t+1}}{1+r_t} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2$$

5. *and the competitive equilibrium conditions give prices* p_t^N *and* w_t*.*

In this framework, the optimal monetary policy is non-tradable inflation stabilization. As in the standard New Keynesian models, price stability eliminates all distortions. This conclusion follows even after the introduction of financial constraints in such construction since when external debt denominated in FC, departing from inflation targeting does not bring about any benefits. However, this policy takes some real resources that tighten the dividend constraint further. Then, it is optimal to minimize inflation costs. However, when the model extended with DC debt, the planner deviates from inflation targeting to impose taxes on foreign lenders.

Corollary 1.1 (The Optimal Monetary Policy). *The optimal monetary policy is inflation stabilization:* $\pi_t^N = \pi^N$.

First, I show how the inefficiencies arise in the competitive equilibrium. In particular why bank-firms remain under-capitalized in a crisis. Unlike private agents, the social planner faces the same financial constraints recognizes that the relative price of non-tradable goods and wages affect the tightness of the dividend constraint. It also distorts capital accumulation. Consequently, the planner builds up capital buffers in regular times to mitigate consumption drop in adverse times.

To formally derive the inefficiencies, I compare the social planner allocations with the that of decentralized equilibrium. Let λ_t and η_t denote the Lagrange multipliers of the resource constraint of non-tradable goods and the dividend constraint. Let us suppose that the policy functions are differentiable. Then, the optimality condition of the social planner to non-tradable goods consumption illustrates the pecuniary externality. It clarifies the main distinctions between the competitive equilibrium and social planner allocations:

$$c_t^N :: \quad u'(t)\frac{dc_t}{dc_t^N} - \lambda_t + \underbrace{\eta_t\left(\left(y_t^N - \chi h_t^{1+\nu}\mathbb{C}_t\right)\frac{dp_t^N}{dc_t^N} - p_t^N \chi h_t^{1+\nu}\frac{d\mathbb{C}_t}{dc_t^N}\right)}_{\textit{Externality}} = 0$$

where $\mathbb{C}_t$ denotes the inverse of the derivative of the aggregate consumption to non-tradable consumption. Private agents take as given the relative price in the competitive equilibrium as given and can not recognize how the consumption of non-tradable goods affects the relative price. However, the planner recognizes its effects on the balance sheet by $\frac{dp_t^N}{dc_t^N}$ and adjusts consumption accordingly. In other words, the social planner relaxes the balance sheet of bank-firms by reducing the consumption of non-tradable goods, thereby alleviating investment drop.

Bank-firms can not internalize how their labor demand affects wages, and that, in turn, affects capital accumulation. They raise wage payments by over-demanding labor. While higher labor demand scales up production, it transfers resources from investment to wage payments. That is why they remain under-capitalized during a crisis. The following first-order condition formally gives the externality due to the labor demand:

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

The planner recognizes that it can turn wages in favor of the balance sheet of bank-firms by taking into account the effects of $\frac{dw_t}{dh_t} h_t$ on the tightness of the constraint. In particular, demanding one more unit of labor increases wages by $\frac{dw_t}{dh_t}$ and decreases profits by $\frac{dw_t}{dh_t} h_t$. Thus, the planner constrains labor demand to facilitate the transfer of funds from wage payments to finance investment. It, in turn, promises higher dividend and wage payments to households in the future periods. By doing so, the planner can raise welfare permanently.

The externalities mentioned above bring about market failure. However, they justify interventions to alleviate the under-capitalization of bank-firms since a tight dividend constraint prevents the flow of resources from households to bank-firms. The policymaker can extract resources from households through lump-sum taxes. This policy completely resolves the pecuniary externality. However, I take the perspective that lump-sum taxes are infeasible, or the administrative costs of them to bail out the production sector prevent the policymaker from implementing this policy. Thus, the paper focuses on optimal bailouts financed through distortionary policies. The following corollary connects lump-sum taxes with optimal bailouts:

Corollary 1.2 (**Lump-Sum Taxes and Optimal Bailouts**). *If the policymaker can impose lump-sum taxes on households to bail out the production sector, the dividend constraint does not bind. Optimal bailouts are* $T_t = \underline{d} - d_t$.

The social planner and the competitive equilibrium allocations coincide in the absence of equity frictions under the inflation stabilization policy. Binding equity constraint generates inefficiency in the model since it restricts the flow of funds from households to the production sector. Without this constraint, bank-firms would be able to raise new equity on households to finance investment. In other words, they would have the same value across households and the production sector. Thus, bailouts would be ineffective.

Proposition 1.1 (**The Planner and The Competitive Equilibrium Allocations**). *The competitive equilibrium under inflation stabilization policy* $\left(\pi_t^N = \pi^N\right)$ *absent equity market frictions* $(\underline{d} = -\infty)$ *coincides with the social planner allocations.*

Proof. The Lagrange multiplier associated with the dividend constraint is zero $(\eta_t = 0)$, when $\underline{d} = -\infty$. Under inflation stabilization, the competitive equilibrium and the planner allocations coincide. □

1.4 Time-Consistent Optimal Policies

This section defines time-consistent optimal policies. The policymaker lacks a commitment to all of its instruments. In other words, the policymaker chooses the policy rules each period by taking as given the policy rules of its future-self. A Markov Perfect Equilibrium is the fixed point of the policy rules that represent the current and future policymakers.

I focus on time-consistent policies since policies under commitment are time-inconsistent for two reasons. First, the policymaker may promise not to reduce the real value of debt through inflation to increase the price of nominal debt, but when debt issued, this promise is not credible. Second, bailouts are optimal ex-post, but they should be limited to mitigate ex-ante moral hazard issues. Promising not to bail out bank-firms is not credible when an adverse financial shock hits.

Unlike Bianchi (2016), I suppose that the policymaker can transfer resources from households and international lenders to bank-firms. First, I consider the case where the policymaker can only impose income taxes on households to finance bailouts and government expenditure. Then, I extend the model by introducing government debt denominated in DC.[20] In this case, the planner has access to inflation and debt policies. Given that bank-firms are exposed to significant FC liabilities, one would expect a conservative exchange rate policy in line with the classical currency mismatch ideas. However, that prediction would be premature since the planner now has perverse incentives to reduce the real value of debt repayment for financial stability. Despite the costs of inflation, the planner can partially finance bailouts.

These exercises highlight the importance of the available set of instruments for optimal policy design. They also show the effectiveness of each policy. The following subsections provide the formal definitions of each policy that corresponds to different model equations.

1.4.1 Optimal Bailout Policies: Equity Injections

The policymaker can accelerate the recapitalization of the production sector in a crisis. The policymaker is now restricted to collect only income taxes from households to finance equity injections.

Definition 1.4 (**Optimal Time-Consistent Equity Injections**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions*

[20] The basic setup could also be extended with FC debt at computational costs. Engel and Park (2017); Ottonello and Perez (forthcoming) study the factors that drive the currency composition of sovereign debt. However, this paper focuses on the optimal finance of bailouts rather than studying the incentive-hedging trade-offs corresponding to the choice of the currency composition. This paper takes as given the currency composition and studies incentives to tax foreign lenders for domestic financial stability. The planner would have strong incentives to dilute the real value of debt repayment as long as debt issued in DC. Hence, the results would still carry through. Other than increasing the grid space substantially, FC external debt would not eliminate the incentive problems to dilute debt repayment. Thus, it would not significantly affect the results. The paper focuses on the incentives to reduce real debt repayment for financial stability.

of its future-self:

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, T_t\}$. T_t *shows the scale of equity injections financed by income taxes* τ_t. *This problem is subject to competitive equilibrium conditions (Equation A.1 - Equation A.21):*

1. *but now the household's budget constraint is replaced by*

$$c_t^T + p_t^N c_t^N = y_t^T + (1 - \tau_t) w_t h_t + d_t$$

2. *the bank-firm's budget constraint is replaced by*

$$\begin{aligned} d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta) k_t - k_{t+1} - \frac{a_k}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t - b_t \\ + \frac{b_{t+1}}{1 + r_t} - \frac{a_p}{2} \left(\pi_t^N - \pi^N \right)^2 + T_t \end{aligned}$$

3. *the government's budget constraint is*

$$T_t = \tau_t w_t h_t$$

4. *the intratemporal labor Euler is replaced by*

$$\chi h_t^\nu = \frac{dc_t}{dc_t^T} (1 - \tau_t) w_t$$

5. *perceived policies coincide with actual policies.*

1.4.2 Optimal Price Support

The policymaker can also increase government expenditure to support the relative price of non-tradable goods. The policymaker is again restricted to fund government expenditure through income taxes. I suppose that the policymaker chooses aggregate government expenditure, then it is allocated to tradable and non-tradable goods in fixed proportion to moderate computational costs such that:

$$g_t^N = \phi g_t, \quad g_t^T = (1-\phi) g_t$$

Then, the price of government expenditure is

$$p_t^g = \phi p_t^N + (1-\phi)$$

Definition 1.5 (**Optimal Time-Consistent Price Support Policies**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self:*

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

where $\Gamma_t \equiv \left\{ c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, g_t \right\}$. g_t *shows government expenditure financed by income taxes* τ_t. *This problem is subject to competitive equilibrium conditions (Equation A.1 - Equation A.21):*

1. *but the household's budget constraint is replaced by*

$$c_t^T + p_t^N c_t^N = y_t^T + (1-\tau_t) w_t h_t + d_t$$

2. *the government's budget constraint is*

$$p_t^g g_t = \tau_t w_t h_t$$

3. *the market clearing condition for non-tradable goods is replaced by*

$$y_t^N = c_t^N + g_t^N$$

4. *the market clearing condition for tradable goods is replaced by*

$$c_t^T + b_t + k_{t+1} + g_t^T = y_t^T + \frac{b_{t+1}}{1+r_t} + (1-\delta)k_t - p_v v_t - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2$$

5. *the intratemporal labor Euler is replaced by*

$$\chi h_t^{\nu} = \frac{dc_t}{dc_t^T}(1-\tau_t)w_t$$

6. *perceived policies coincide with actual policies.*

To see the impact of an increase in government expenditure in the relative price of non-tradable goods, plug in the market clearing condition for non-tradable goods into Equation 1.2.3 gives:

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

The expansionary fiscal policy supports the relative price that can also alleviate the under-investment in the production sector. The fiscal multiplier, however, can be state-dependent and highly non-linear.

1.4.3 Optimal Debt and Inflation

I extend the basic setup by introducing long-term nominal government debt motivated by the recent trend in the share of the external government debt denominated in DC in the developing world. Now, the policymaker also has access to debt policy and an inflation tax that reduces the real value of its nominal liabilities to foreign lenders together with income taxes, and government expenditure.

I follow the sovereign debt literature and model the long-term government debt denominated in DC as a perpetuity contract with coupon payments. In particular, bonds issued in the current period pay an infinite stream of coupons decreasing at an exogenous constant rate ζ following Ottonello and Perez (forthcoming); Hatchondo and Martinez (2009); Arellano and Ramanarayanan (2012); Chatterjee and Eyigungor (2012). The decay rate ζ also determines the average duration of bonds. The short term debt corresponds to the particular case $\zeta = 0$. The maturity of debt increases with ζ. In particular, issuing one unit government debt in DC in the current period promises the following cash flows in the next periods $t+1$, $t+2$, ...:

$$\left[1,\ \zeta,\ \zeta^2,\ ...\right]$$

In exchange, the policymaker receives q_t units in DC now. The main advantage of this formulation of the long-term debt is that future payments can be condensed into a one-dimensional state variable, the number of coupon payments that mature in the current period.

There is a continuum of identical risk-neutral international lenders.[21] They have complete information regarding the economy's fundamentals. Thus, foreign lenders value DC cash flows in FC as follows:

$$\left[\frac{1}{e_{t+1}},\ \frac{\zeta}{e_{t+2}},\ \frac{\zeta^2}{e_{t+3}},\ ...\right]$$

Foreign lenders behave competitively and expect zero profit at equilibrium. They can either invest in the risk-free asset that pays a net real return r^* in FC or government bond denominated in DC. The policymaker can not commit to its future policies and may reduce the real value of its nominal claims to foreign lenders through an inflation tax. Thus, the price of nominal claims depends on the dilution risks at equilibrium. In particular, the equilibrium price of nominal debt decreases with the anticipated dilution risks. In other

[21] I also consider the case where risk-averse foreign lenders price the debt.

words, the payoff depends on the expected inflation. The arbitrage condition gives that the expected dilution risk premia are equalized with the return of the risk-free asset. Thus, the price of DC debt given is

$$q_t = \frac{1}{1+r^*}\mathbb{E}_t\left[\frac{e_t}{e_{t+1}}\left(1+\zeta q_{t+1}\right)\right] \tag{1.4.1}$$

Besides, the price of DC debt in terms of tradable goods is

$$q_t^* = \frac{q_t}{e_t} = \frac{1}{1+r^*}\mathbb{E}_t\left[\frac{1}{e_{t+1}} + \zeta q_{t+1}\right]$$

To compute the country spread, I first calculate the yield to maturity ratio of nominal bonds:

$$r_t^c = \frac{1}{q_t^*} + \zeta - 1$$

Then, the country spread on the risk-free global rate is $r_t^c - r^*$.

The policymaker now starts the period with outstanding debt B_{gt} denominated in DC. The policymaker issues nominal debt $[B_{gt+1} - \zeta B_{gt}]$ by taking q_t as given. If $[B_{gt+1} - \zeta B_{gt}] < 0$, the policymaker repurchases the long-term bonds. Otherwise, the policymaker promises to make coupon payments in future periods.

Besides, the following equality gives the domestic currency depreciation:

$$\frac{p_t^N}{p_{t-1}^N} = \frac{P_t^N/e_t}{P_{t-1}^N/e_{t-1}} = \frac{\pi_t^N}{\epsilon_t} \tag{1.4.2}$$

given p_{t-1}^N. The government's budget constraint in nominal terms is

$$P_t^T(1-\phi)g_t + P_t^N\phi g_t + B_{gt} = \tau_t W_t h_t + q_t\left(B_{gt+1} - \zeta B_{gt}\right)$$

Then, the budget constraint in terms of tradable goods is

$$p_t^g g_t + \frac{b_{gt}}{\epsilon_t} = \tau_t w_t h_t + \frac{1}{1+r^*}\mathbb{E}_t\left\{\frac{1}{\epsilon_{t+1}}(1+\zeta q_{t+1})\right\}\left(b_{gt+1} - \zeta\frac{b_{gt}}{\epsilon_t}\right) \tag{1.4.3}$$

where $b_{gt} = \frac{B_{gt}}{e_{t-1}}$.

Definition 1.6 (**Optimal Time-Consistent Debt and Inflation**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self:*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, g_t, \pi_t^N, b_{gt+1}, \epsilon_t\right\}$ *and subject to competitive equilibrium conditions (Equation A.1 - Equation A.21):*

1. *the household's budget constraint is replaced by*

$$c_t^T + p_t^N c_t^N = y_t^T + (1-\tau_t) w_t h_t + d_t$$

2. *the government's budget constraint is*

$$p_t^g g_t + \frac{b_{gt}}{\epsilon_t} = \tau_t w_t h_t + \frac{1}{1+r^*} \mathbb{E}_t \left\{ \frac{1}{\epsilon_{t+1}} (1 + \zeta q_{t+1}) \right\} \left(b_{gt+1} - \zeta \frac{b_{gt}}{\epsilon_t} \right)$$

3. *the market clearing condition for tradable goods is replaced by*

$$\begin{aligned} c_t^T + b_t + \frac{b_{gt}}{\epsilon_t} + k_{t+1} + g_t^T = y_t^T + \frac{b_{t+1}}{1+r_t} + \frac{1}{1+r^*} \mathbb{E}_t \left\{ \frac{1}{\epsilon_{t+1}} (1 + \zeta q_{t+1}) \right\} \left(b_{gt+1} - \zeta \frac{b_{gt}}{\epsilon_t} \right) \\ + (1-\delta) k_t - p_v v_t - \frac{a_k}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t - \frac{a_p}{2} \left(\pi_t^N - \pi^N \right)^2 \end{aligned}$$

4. *the market clearing condition for non-tradable goods is replaced by*

$$c_t^N + g_t^N = y_t^N$$

5. *the intratemporal labor Euler is replaced by*

$$\chi h_t^{\nu} = \frac{dc_t}{dc_t^T} (1 - \tau_t) w_t$$

6. *the bond price is given by Equation 1.4.1.*

7. perceived policies coincide with actual policies.

Proposition 1.2 (**Market Shutdown**). *Absent endogenous costs of inflation $a_p = 0$, positive debt in equilibrium can not be sustainable. Thus, the government debt market is shut down.*

Proof. The policymaker lacks a commitment to its policies. Without the costs of inflation, the policymaker finds it optimal to ultimately dilute the real value of its debt to international lenders, but rational foreign lenders predict this incentive and will lend at zero price. □

1.4.4 Optimal Debt, Inflation and Bailouts

The policymaker can now also rely on not only the fiscal policy but also the monetary policy to finance bailouts. In other words, the policymaker can extract resources from international lenders through an inflation tax and transfer those resources to the production sector. Thus, domestic currency depreciation may provide financial stability. This policy enhances the balance sheet of the private sector. Domestic equity market frictions, together with bailouts, allow inflationary policies in contrast with the predictions of the classical currency mismatch approach.

Accordingly, the policymaker chooses bailouts in addition to the policies chosen in the previous section. This exercise reveals the relative effectiveness of this policy. Also, it shows how bailouts affect the incentives to reduce the real value of outstanding obligations to foreign lenders.

Definition 1.7 (**Optimal Time-Consistent Debt, Inflation and Bailouts**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived* *policy functions of its future-self:*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, g_t, \pi_t^N, T_t, b_{gt+1}, \epsilon_t\right\}$ *and subject to competitive equilibrium conditions. Some equations in the previous section are adjusted as follows:*

1. *the government's budget constraint is*

$$p_t^g g_t + \frac{b_{gt}}{\epsilon_t} + T_t = \tau_t w_t h_t + \frac{1}{1+r^*}\mathbb{E}_t\left\{\frac{1}{\epsilon_{t+1}}(1+\zeta q_{t+1})\right\}\left(b_{gt+1} - \zeta\frac{b_{gt}}{\epsilon_t}\right)$$

2. *the bank-firm's budget constraint is*

$$\begin{aligned} d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t \\ + \frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 + T_t \end{aligned}$$

3. *perceived policies coincide with actual policies.*

1.4.5 Optimal Capital Controls

To show how capital controls affect dilution risks and ex-ante risk-taking, I suppose that the policymaker can also choose capital inflow taxes together with the policies expressed in the previous section. Capital controls limit borrowing, thereby affecting expected bailouts and dilution risks.

Definition 1.8 (**Optimal Time-Consistent Capital Controls**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self:*

$$V(S_t) = \max_{\Gamma_t} \quad u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})$$

where $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, \tau_t^c, g_t, \pi_t^N, T_t, b_{gt+1}, \epsilon_t\right\}$. τ_t^c *shows capital inflow taxes. This problem is subject to competitive equilibrium conditions. Some equations in the previous section are adjusted as follows:*

1. *the government's budget constraint is replaced by*

$$p_t^g g_t + \frac{b_{gt}}{\epsilon_t} + T_t = \tau_t w_t h_t + \tau_t^c \frac{b_{t+1}}{1+r_t} + \frac{1}{1+r^*}\mathbb{E}_t\left\{\frac{1}{\epsilon_{t+1}}(1+\zeta q_{t+1})\right\}\left(b_{gt+1} - \zeta\frac{b_{gt}}{\epsilon_t}\right)$$

2. *the bank-firm's budget constraint is replaced by*

$$\begin{aligned} d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t \\ + (1-\tau_t^c)\frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 + T_t \end{aligned}$$

3. *the first-order-condition to* b_{t+1} *is replaced by*

$$(1+\eta_t)(1-\tau_t^c) = (1+r_t)\beta\mathbb{E}_t m(S_t, S_{t+1})(1+\eta_{t+1}) + \mu_t$$

   where μ_t *and* η_t *show the Lagrangian multipliers associated with the collateral and dividend constraints, respectively.*

4. *perceived policies coincide with actual policies.*

1.5 Quantitative Analysis

1.5.1 Solution Method

I solve the model by global solution methods since the policy functions are not differentiable because of the occasionally binding constraints, unlike setup in Klein, Quadrini and Rios-Rull (2005). The competitive equilibrium is solved by policy function iteration. Optimal time-consistent policies are solved by value function iteration as in Benigno et al. (2013).

Cubic B-splines outside the grid points approximate policy functions and their derivatives.

1.5.2 Calibration

There are three exogenous states $\left(y_t^T, r_t, \kappa_t\right)$. The interest rate is computed as the total of the EMBI spread and the US T-bill rate. The tradable sector consists of manufacturing, agriculture, mining, and forestry. I suppose that the financial shock is exogenous to interest rate and tradable endowment. Thus, the following bivariate VAR(1) process is estimated:

$$\begin{bmatrix} log\left(y_t^T\right) \\ log\left(\frac{1+r_t}{1+r}\right) \end{bmatrix} = A \begin{bmatrix} log\left(y_{t-1}^T\right) \\ log\left(\frac{1+r_{t-1}}{1+r}\right) \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

the errors are distributed by $\mathcal{N}(0, \Sigma)$. I use the cyclical component of $log\left(y_t^T\right)$. The coefficient and covariance matrices are given by:

$$A = \begin{bmatrix} 0.94 & 0.00 \\ 0.02 & 0.81 \end{bmatrix}; \qquad \Sigma = \begin{bmatrix} 2e-4 & -5e-5 \\ -5e-5 & 2e-4 \end{bmatrix};$$

I estimate the transition probabilities by simulation methods.[22]

I calibrate the model to match the critical moments of an average economy from 1980 through 2015. I report parameter values in Table 1.3, use the standard values for σ, ν, α_k, α_v, α_h, r^*, γ, and target capital/output ratio and investment/output ratio for β and δ. χ and z are calibrated to normalize the employment, and the non-tradable output to 1. a captures the consumption share of non-tradable goods. Cruces and Trebesch (2013) document that the average duration of bonds in the emerging market is four years, thereby ζ is calibrated to 0.76. I suppose that bank-firms can not raise new equity from households in a crisis and set $\underline{d} = 0$. a_k and a_p match the standard deviation of investment/output ratio and the standard

[22] See subsection A.5 for the transition matrix.

deviation of the non-tradable inflation.[23] I calibrate r^* to 4%, and the share of non-tradable goods in government expenditure to 0.90. I do not have data for the share of non-tradable goods in government expenditure. Thus, I solve the model with different values to show its effects on model dynamics and check the robustness of results.

1.5.3 Results

Competitive Equilibrium

I first consider the case where domestic equity constraint is always slack ($\underline{d} = -\infty$) and then solve the model with domestic financial frictions. These exercises illustrate how a binding equity constraint calls for interventions.

Figure 1.2 shows the equilibrium policy functions for the next period debt and the next period capital as a function of the debt in the current period. The dashed blue and black lines plot the law of motions in the high borrowing regime when tradable endowments and interest rates are at their mean values. The debt choice is increasing with the current level of debt in both cases. However, an adverse financial shock leads to a sudden reversal. Debt choice is decreasing with the current level of debt as investment cuts down in the tight credit regime since bank-firms can not finance the desired level of investment.

The right panel shows capital accumulation. It is strictly diminishing with the debt level in the current period, even in the high borrowing regime, since the probability of a future binding constraint is increasing with the current level of debt. It disincentivizes bank-firms to increase borrowing to finance investment. In other words, the risk premium of investment increases with the current level of debt, thereby leading to lower resources allocation to investment.

[23] The CPI of different categories is reported in the national sources. I compute the non-tradable inflation as the log change of the weighted CPIs of different categories.

While capital accumulation decreases with the current level of debt in both cases, binding dividing constraint results in strike differences between policy functions. Absent domestic financial frictions banks-firms can raise new equity from households to finance the desired level of investment in the tight external borrowing regime. However, domestic financial frictions restrict the flow of funds from households to the production sector. While resources are more valuable in the production sector in the tight credit regime, households are not willing to transfer resources to the production sector since they can not recognize that by doing so, they can receive higher dividend and wage payments in the future. Therefore, domestic financial frictions put pressure on bank-firms to further cut down investment. These constraints generate scope for government interventions since a policymaker can facilitate the transfer of funds from households to bank-firms. Thus, interventions can accelerate the recapitalization in the production sector.

Figure 1.3 shows the ergodic distributions of the next period debt and capital in both cases. I simulate the model 100,000 times and discard 10,000 as burn-in to compute the limiting distributions. The limiting distribution of debt in the second case is on the left of the distribution of debt in the first case. Distributions reflect the precautionary incentives when domestic financial frictions exist. In particular, bank-firms further reduce external borrowing in the second case to decrease the probability of hitting the equity constraint in the future. Domestic financial frictions make bank-firms more cautious since binding dividend constraint leads to a very sharp drop in investment. The limiting distributions in both cases have fat tails on the left that captures the precautionary incentives due to the external borrowing constraint. Binding external borrowing constraint also reduces investment as well as consumption. Therefore, bank-firms also try not to hit the borrowing constraint. The limiting distributions of capital in both cases look similar since the capital adjustment is costly, thereby bank-firms tend to adjust debt.

Constrained Efficiency

As discussed qualitatively in the constrained efficiency section, bank-firms under-invest in the competitive equilibrium. I also quantitatively solve the social planner's problem. Then, I compare the efficient allocations with that of the decentralized equilibrium. Unlike private agents, the social planner recognizes how labor demand affects the relative price of non-tradable goods and wages, which in turn affects the tightness of the dividend constraint.

Figure 1.4 plots the equilibrium policy functions of the decentralized equilibrium and the social planner's problem as a function of the current level of debt. Next period debt decreases with the current level of debt in the tight external borrowing regime. However, the social planner can borrow more compared to the competitive equilibrium since the planner internalizes that reducing labor demand turns the relative price and wage in favor of bank-firms. In particular, wages decrease more sharply when dividend constraint binds in the planner's problem. Furthermore, the relative price of non-tradable goods rises non-linearly more in the planner's problem than that of the competitive equilibrium, since the relative price increases with the lower consumption of non-tradable goods. The social planner internalizes pecuniary inefficiencies, thereby restricting employment and the consumption of non-tradable goods. By doing so, the planner turns prices in favor of the production sector.

Optimal Time-Consistent Policies

I first solve the case in which the policymaker can only collect income taxes from households to finance bailouts and government expenditure. I also fix the income tax rate and suppose that tax revenue transferred to bank-firms' balance sheets as lump-sum payments. I then solve the extended setup to compare welfare gains under each policy.

Figure 1.6 shows the law of motions for policy functions as a function of the current level of debt when capital stock, tradable endowments, and interest rates are at their mean values. $\mathrm{OP}(T_t)$ and $\mathrm{OP}(g_t)$ denote optimal bailouts and the price support policy, respectively. $\mathrm{DE}(\overline{\tau}_t)$ shows the competitive equilibrium in which income taxes are fixed.

Investment drops very sharply in the tight credit regime, which also undermines the borrowing capacity of bank-firms. However, optimal bailouts (dashed red line) and the price support policy (dashed black line) alleviates the adverse effects of financial shocks. The quantitative analysis shows that the policymaker finds it optimal to carry out bailouts when the dividend constraint binds. However, it is optimal to increase government expenditure at very high debt levels. Only income taxes also finance government expenditure. The costs of distortionary taxation outweigh the benefits of higher government expenditure at moderate debt levels. I find that the price support policy leads to a higher relative price of non-tradable goods than bailouts do. However, bailouts allow for a quicker recovery from a contraction than the price support policy does since bailouts turn not only the relative price of non-tradable goods but also wage in favor of bank-firms.

I set the income tax rate to 0.15 and suppose that tax revenue is transferred to bank-firms' balance sheets to reveal the relative effectiveness of optimal policies. This policy leads to lower employment, non-tradable output, and wage, but higher relative price of non-tradable goods in the high borrowing regime than that optimal bailouts and the price support policy do. However, in the tight credit regime, optimal policies are further effective in turning wages and the relative price of non-tradable goods in favor of bank-firms. In other words, the policymaker further accelerates the transfer of resources from wage payments to investment by allowing higher income taxes in optimal policies than the fixed tax rate.

Figure 1.7 shows the non-linear impulse response functions. To draw these figures, I simulate the shock process for 50,000 times for 15 periods. The impulse response functions show the average differences between the policy functions in the high and tight credit regimes. I fix other exogenous and endogenous variables at their mean values and take the adverse financial shock as an initial value in the first simulation. The second simulation begins with a positive financial shock. After simulating the shock processes, I approximate endogenous variables using the cubic spline interpolation method and then compute the average differences between policy functions.

Next period debt and capital drop very sharply. Bailouts and price support policies alleviate the adverse effects of financial shocks. However, I find that bailouts allow for a quicker recapitalization in the production sector than the price support policy does. I also find that the optimal scale of bailouts is about 4% of GDP. Income taxes increase by about 40% to finance bailouts. The price support policy has little effects on recapitalization. An adverse financial shock increases government expenditure by about 8% of GDP to relax the relative price. This policy also leads to a smaller increase in income taxes. They increase by about 20% to finance government expenditure. Bailouts are much more effective in accelerating capitalization in the production sector since the price support policy only corrects the inefficiency through the relative price, but not the wage.

Figure 1.8 shows the event window of a crisis, to construct it, I simulate the variables for 50,000 periods, and then discard 10,000 periods as burn-in. I follow the macro-finance literature to identify a crisis. In particular, a crisis is identified when external credit falls below its two standard deviations. I then take 15 periods before and after the crisis and compute the mean deviation of each variable from its pre-crisis value. The event window shows substantial moral hazard issues. Anticipated bailouts build up higher leverage in pre-crisis that eventually brings about more severe contractions. Bailouts financed through fixed income taxes also lead to higher leverage in pre-crisis than the price support policy does.

I also consider the case in which the policymaker can impose capital inflow taxes to alleviate moral hazard issues. Figure 1.10 shows policy functions under the case that the policymaker can impose debt taxes together with bailouts still financed through income taxes. I find that capital flow taxes are only favorable at the onset of a crisis. Therefore, policy functions look very similar. The distribution of debt in a model with capital controls is on the left of distribution with only bailouts, as shown in Figure 1.11.

I then solve the extended set up to show how the incentives to reduce the real value of nominal claims to foreign lenders affect model dynamics. In this case, the policymaker can extract resources not only from households through income taxes but also from international lenders through an inflation tax. These exercises show that the available set of instruments is essential for optimal policy design. Accordingly, I first consider the inflation stabilization case. I then examine the optimal inflation and debt policies. Lastly, I consider the case where the policymaker can carry out bailouts.

The above-mentioned quantitative results show that interventions financed by only income taxes can not adequately maintain financial stability since it is very costly to increase income taxes when the marginal utility of consumption is very high. However, the policymaker can now extract extra resources from international lenders through an inflation tax when it is no longer optimal to extract resources through fiscal policy.

Figure 1.12 shows the exchange rate in three different cases. The exchange rate increases with the current debt level under inflation stabilization since consumption allocations still affect the relative price of non-tradable goods. When the policymaker chooses inflation, I find sharper depreciation. However, when bailouts are available, the domestic currency further depreciates in contrast with the predictions of the classical currency mismatch literature.

Figure 1.13 shows inflation and the price of nominal government debt in the tight credit regime. The policymaker tends to increase inflation as current government debt increases under both optimal inflation policy (solid blue line) and bailouts (dashed red line). Absent endogenous costs of inflation, the policymaker would sufficiently dilute the real value of its nominal debt. Bailouts reduce the costs of inflation policy. Since it is very costly to increase the income tax rate when constraints are binding, the government relies on the exchange rate policy and allows more substantial depreciation compared to the model without bailouts. Rational international lenders anticipate the incentives and buy bonds at a lower price. Also, dilution risks are increasing with government debt, thereby the price of nominal bonds is strictly decreasing with government debt.

1.6 Extensions

1.6.1 Inflation-Linked Debt

Now, I suppose that the government issues inflation-linked debt to mitigate ex-ante moral hazard problems. In particular, issuing one unit government debt in DC in the current period promises the following cash flows in the next periods $t+1$, $t+2$, ...:

$$\left[\pi_{t+1},\ \zeta\pi_{t+2},\ \zeta^2\pi_{t+3},\ ...\right]$$

Rational foreign lenders value DC cash flows in FC as follows:

$$\left[\frac{\pi_{t+1}}{e_{t+1}},\ \frac{\zeta\pi_{t+2}}{e_{t+2}},\ \frac{\zeta^2\pi_{t+3}}{e_{t+3}},\ ...\right]$$

Since international lenders expect zero profit at the equilibrium, the bond price is given by

$$q_t = \frac{1}{1+r^*}\mathbb{E}_t\left[\frac{e_t\pi_{t+1}}{e_{t+1}}\left(1+\zeta q_{t+1}\right)\right]$$

The inflation-linked debt moderates the incentives to reduce the real value of claims to foreign lenders. Thus, the policymaker is now restricted to allow for higher inflation for financial instability.

1.6.2 Financial Repression

Financial repression refers to the policies that the government can force bank-firms to hold more government debt in their portfolios than they would absent this policy. Now, I suppose that a constant fraction ϖ of DC debt held by bank-firms. For a broad set of parameter values, the capital return is higher than the government debt yield. Thus, bank-firms are not willing to hold nominal debt, but the government may force them. Becker and Ivashina (2017); Broner et al. (2014); Reinhart (2012); Reinhart and Sbrancia (2015) show that political pressure is the main reason for the growing share of government debt in bank-firms' portfolio in many countries.

In that case, the budget constraint of bank-firms given by:

$$d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + \frac{b_{t+1}}{1+r_t}$$
$$-\frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 + \varpi\frac{b_{gt}}{\epsilon_t} - \varpi\frac{1}{1+r^*}\mathbb{E}_t\left\{\frac{1}{\epsilon_{t+1}}(1+\zeta q_{t+1})\right\}\left(b_{gt+1} - \zeta\frac{b_{gt}}{\epsilon_t}\right)$$

Incentives to lower the debt burden in order to provide funds to the production sector are mitigated since it is more costly to reduce the real value of nominal debt now. I find the benefits of bailouts are smaller when a fraction of nominal debt is placed on bank-firms' balance sheets.

1.6.3 The Risk Averse Pricing of Government Debt

I now relax the risk-neutral foreign lenders hold government bonds assumption, and follow sovereign debt literature and introduce an endogenous risk premium. The pricing kernel of international lenders is

$$M(S_t, S_{t+1}) = exp\left(-r^* - \varrho s_{t+1}\right)$$

where ϱ shows the sensitivity of the lenders' pricing kernel to the log difference in tradable endowments.

I find that when risk-averse foreign lenders price debt, welfare gains are smaller.

1.7 Welfare Analysis

I compute welfare gains to compare the relative effectiveness of each optimal policy and report them as a percentage increase in aggregate consumption. In other words, it is the percent change in aggregate consumption needed to make households indifferent between the optimal policies and the competitive equilibrium allocations.

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t(1+\rho) - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} \tag{1.7.1}$$

where ρ shows welfare gains as a percent of aggregate consumption.

Figure 1.15 shows the welfare gains when bailouts and government expenditure financed through only income taxes. Bailouts yield higher welfare gains than the price support policy and the competitive equilibrium with fixed tax rates do. Panel B denotes the welfare gains when an inflation tax, together with income taxes, finance interventions. I find higher welfare gains when both fiscal and monetary policies finance bailouts.

Figure 1.16 shows the welfare gains of extensions. I find that welfare gains decrease significantly when risk-averse international lenders price the government debt (Risk-averse). Besides, when the policymaker links debt payoffs to inflation, I find smaller welfare gains (Inflation). A significant fraction of government debt shown in bank-firms' portfolios urges policymakers to allow smaller depreciation raising much smaller welfare gains (Repression).

1.8 Empirical Evidence

This section documents the relationship between FC liability and government policies in emerging economies in a systemic banking crisis. I use annual data covering the period 1980-2015 for twenty-two emerging market economies.[24] The data of output, consumption, investment, exchange rate, tax revenue, government debt are from World Development Indicators (WDI), World Economic Outlook (WEO) databases, and national sources. The systemic banking crisis dates are from Valencia and Laeven (2015). Benetrix, Agustin and Shambaug (2015) provide the FC liability data as percent of GDP and currency weight.

Figure 1.19 shows the cross-country medians of the cyclical components in a five-years event window centered at date 0.[25] The main characteristic of a banking crisis is a significant deviation of a macro variable from its trend. In particular, several years of expansion precedes a banking crisis. However, a crisis leads to a sudden reversal.

The event window documents a sharp DC depreciation in a crisis, and the currency starts to recover its losses very gradually. The log difference of the nominal exchange rate between the previous and current periods gives the depreciation rate. Tax revenue negatively deviates from the trend that may undermine the fiscal capacity of a government to finance bailouts. Government debt climbs rapidly above the trend when a crisis hits.

Table 1.1 reports the correlation coefficients between the lag of the FC liability and depreciation, inflation, tax revenue, and government debt. The DC depreciation, inflation, and government debt (tax revenue) on average are positively (negatively) correlated with the lag of FC liability. More substantial pre-crisis FC liability corresponds to more considerable depreciation and inflation in crisis times despite the currency mismatch effects.

[24]**Emerging countries:** Argentina, Brazil, Chile, Colombia, Costa Rica, Hungary, Indonesia, India, Korea, Lithuania, Latvia, Mexico, Malaysia, Peru, Philippines, Poland, Russia, Singapore, Slovak Republic, Slovenia, Thailand, Turkey.

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

Table 1.2 reports the regression results corresponding to the log of bailouts as a percent of financial assets and the lag of the FC liability for the whole sample. Each observation is a crisis.[26] The pre-crisis FC liability significantly drives bailouts during a crisis. This conclusion is robust as more control variables added to the analysis, such as exports, reserves, tax revenue, and government debt. Total reserves excluding gold in pre-crisis are associated with a smaller scale bailout package in a crisis. Governments could use foreign reserves to alleviate the domestic currency depreciation in a crisis that would eventually call for a smaller scale intervention. However, exports, tax revenue, and government debt in pre-crisis are found not good predictors of bailouts during a crisis.

The empirical analysis shows the strong relationship between pre-crisis foreign currency liability, domestic currency depreciation, and bailouts during a crisis in stark contrast with the predictions of the currency mismatch argument. Given the recent trend in the currency composition of debt in the emerging world, high levels of government debt in DC, on the one hand, provides insurance in recessions. On the other hand, it may induce governments to depreciate domestic currency to dilute debt excessively. The following sections present the theoretical framework and study the trade-offs associated with the use of exchange rate policy for financial stability.

1.9 Conclusion

This paper studies the optimal way to finance bailouts in the emergency need for abundant resources to recapitalize the production sector. While bailouts funded only through income taxes also alleviate the under-capitalization in the production sector, I find that it is optimal to support fiscal policy with monetary policy to finance them since monetary policy

[26] There are not many observations for each country. Thus, I report the regression results on crisis episodes.

can also extract extra resources from international lenders.

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A Appendix

A.1 Feasible Debt Space

The maximum level of debt of bank-firms that guarantees that consumption allocations are positive, and constraints are not violated is computed for each given capital stock. It is essential to find out the available debt space for any given capital stock since the numerical algorithm searches for equilibrium allocations within the available space. This section provides the algorithm to find the maximum debt level in the worst exogenous state: y^T_{min}, r_{max} and κ_{min}. Let $b_f(k)$ denote the maximum debt level that the economy can sustain in the worst exogenous state. The following algorithm gives the feasible space as a function of capital stock:

$$b_{ft}(k_t) = \max_{\Gamma_t} \left\{ p^N_t y^N_t - w_t n_t - p_v v_t - \underline{d} + \frac{b_{t+1}}{1 + r_{tmax}} + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t \right\}$$

where $\Gamma_t \equiv \{b_{t+1}, k_{t+1}, h_t, v_t\}$ and subject to

$$\frac{b_{t+1}}{1 + r_{tmax}} + \theta p_v v_t \leq \kappa_{tmin} k_{t+1}$$

where p^N_t and y^N_t are given by Equation 1.2.3 and Equation 1.2.4 respectively.

Households and bank-firms' optimal conditions gives the optimal labor and imports demand as the solution of the following non-linear equations:

$$\frac{\chi h^\nu_t}{dc_t/dc^T_t} = \frac{\alpha_h(\gamma - 1)p^N_t y^N_t (1 + \tau_y)}{\gamma h_t}$$

and

$$p_v(1 + \theta) = \frac{\alpha_v p^N_t y^N_t}{\alpha_h v_t}$$

Market clearing conditions for tradable and non-tradable goods are

$$c_t^T = y_{tmin}^T - p_v v_t - b_{ft}(k_t) + \frac{b_{t+1}}{1 + r_{tmax}} + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t$$

and

$$c_t^N = y_t^N$$

The feasible set is

$$\Theta = \{(b, k) \in \mathbb{R} \times \mathbb{R}, b \leq b_f(k)\}$$

The following numerical algorithm finds the maximum sustainable debt:

1. For given k, guess $b_{f,s}$ where $s = 0$ is the iteration number.

2. Using the above-described procedure, find $b_{f,s}$ at the iteration s.

3. Make sure that the tradable consumption is not negative.

4. Check convergence such that $sup_k\left[b_{f,s}(k) - b_{f,s-1}(k)\right] < \varepsilon$.

5. If not converged, start from step 2 and iterate until converges.

Figure 1.1 plots the feasible debt space. The maximum debt that the economy can sustain is increasing with the current capital stock. In the quantitative analysis, I find that the ergodic distributions of the next period debt choice are within the feasible debt space.

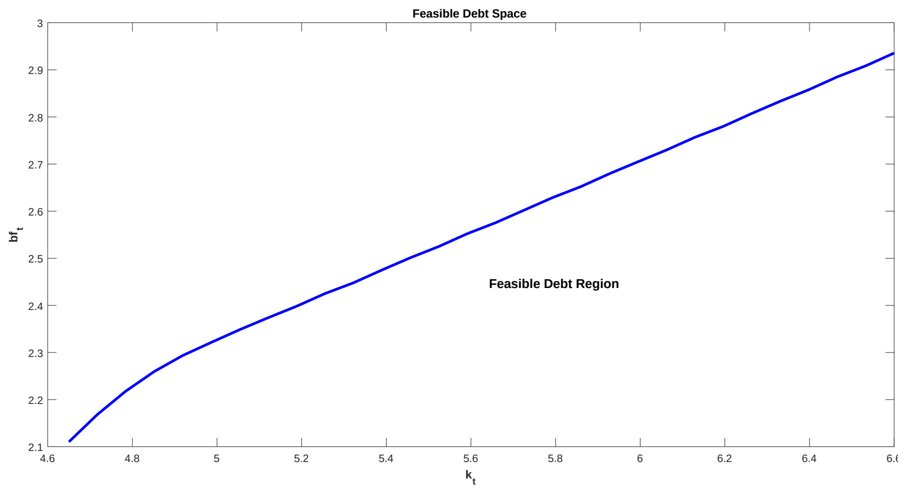

Figure 1.1: The feasible debt space.

A.2 Numerical Algorithm

Competitive Equilibrium

I solve the competitive equilibrium allocations by the Euler equation method based on policy function iteration given government policies. I use the cubic B-spline interpolation methods to approximate policy functions outside grid points.

The computational algorithm is

1. Grid Points:

   First, I generate discrete grids for the aggregate state space: s_t x B_t x K_t

2. The Feasible Debt Space:

   I find the maximum debt level the economy can sustain in each capital stock given government policies as in the subsection A.1.

3. Initial Guesses:

   I determine initial guesses for policy functions as steady-state values and compute expectations using these guesses.

4. The Equilibrium Policy Functions:

   I find the competitive equilibrium allocations by policy function iteration as follows

   (a) Suppose that only the borrowing constraint binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (b) Suppose that only the dividend constraint binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not continue with the following step.

   (c) Suppose that both collateral and dividend constraints bind, then solve for the equilibrium allocations. Check whether constraints bind. If not continue with the following step.

   (d) Suppose that both constraints are slack, then solve for the equilibrium allocations.

5. Expectations:

   I update agents' conditional expectations.

6. Convergence:

   I repeat from item 4 to item 5, until expected values and policy functions converge.

Time-Consistent Optimal Policies

The planner maximizes the representative household's value function. I find the optimal policies that are subject to competitive equilibrium and resource constraints by value function iteration method.

The algorithm searches for time-consistent optimal policies. In other words, the algorithm searches for the fixed points of the policy functions that represent current and future policymakers. Therefore, given current and future policymakers' policies, private agents adjust their expectations and find their optimal reactions to the government's policies. Given the agents' expectations and policymakers' future policies, the current policymaker maximizes agents' welfare. The algorithm stops when current and future policymakers' policies coincide.

I am approximating expected value functions, value functions, and the price of the government debt. The algorithm iterates two loops. The outer loop iterates on expectations, while the inner loop iterates on the policymaker's value function.

1. Grid Points:

   First, I generate discrete grids for the aggregate state space: s_t x B_t x K_t x B_{gt}.

2. The Feasible Debt Space:

   I find the maximum debt level the economy can sustain in each capital stock given government policies as in the subsection A.1.

3. Initial Guesses:

   I determine initial guesses for policy functions as steady-state values and compute expectations using these guesses.

4. The Equilibrium Policy Functions:

   I find the competitive equilibrium allocations by policy function iteration as follows

   (a) Suppose that only the borrowing constraint binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

(b) Suppose that only the dividend constraint binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not continue with the following step.

(c) Suppose that both collateral and dividend constraints bind, then solve for the equilibrium allocations. Check whether constraints bind. If not continue with the following step.

(d) Suppose that both constraints are slack, then solve for the equilibrium allocations.

5. Optimal Policies Given The Policy Functions:

   Given the agents' policy functions, I compute the welfare and then choose the policies $\Omega(S_t)$ that maximize the welfare at each grid point.

6. Converge of The Value Function:

   I repeat item 5 until the value function converges.

7. Expectations:

   Given the policy functions corresponding to the optimal policies computed in item 6, I update agents' expectations.

8. Convergence:

   I repeat from item 4 to item 7, until agents' expectations, the value function and policy functions converge.

A.3 Other Time-Consistent Optimal Policies

Optimal Bailout Policies: Debt Guarantees

Now, I suppose that the policymaker can also pay a fraction of FC liabilities. Income taxes also finance this policy.

Definition 1.9 (**Optimal Time-Consistent Debt Guarantees**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self:*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, \psi_t\right\}$ ψ_t *shows the fraction of debt payments by the government. This problem is subject to competitive equilibrium conditions (Equation A.1 - Equation A.21):*

1. *but now the household's budget constraint is replaced by*

$$c_t^T + p_t^N c_t^N = y_t^T + (1 - \tau_t) w_t h_t + d_t$$

2. *the bank-firm's budget constraint is replaced by*

$$\begin{aligned} d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta) k_t - k_{t+1} - \frac{a_k}{2} \left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - (1 - \psi_t) b_t \\ + \frac{b_{t+1}}{1 + r_t} - \frac{a_p}{2} \left(\pi_t^N - \pi^N\right)^2 \end{aligned}$$

3. *the government's budget constraint is*

$$\psi_t b_t = \tau_t w_t h_t$$

4. *the intratemporal labor Euler is replaced by*

$$\chi h_t^\nu = \frac{dc_t}{dc_t^T} (1 - \tau_t) w_t$$

5. *the first-order-condition to b_{t+1} is replaced by*

$$(1+\eta_t) = (1+r_t)\beta \mathbb{E}_t m(S_t, S_{t+1})\left(1+\eta_{t+1}\right)\left(1-\psi_{t+1}\right) + \mu_t$$

6. *perceived policies coincide with actual policies.*

Optimal Equity Injections and Capital Controls

The policymaker may find it optimal to limit ex-ante borrowing since higher FC debt leads to higher bailout payments. In particular, equity injections accelerate the recapitalization in the production sector, but anticipated interventions increase ex-ante risk-taking. Thereby, I examine the effects of capital controls on ex-ante risk-taking.

Definition 1.10 (**Optimal Time-Consistent Equity Injections and Capital Controls**)**.** *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self:*

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

where $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, T_t, \tau_t^c\right\}$ τ_t^c shows capital inflow taxes. This problem is subject to competitive equilibrium conditions (Equation A.1 - Equation A.21):

1. *but now the household's budget constraint is replaced by*

$$c_t^T + p_t^N c_t^N = y_t^T + (1-\tau_t) w_t h_t + d_t$$

2. *the bank-firm's budget constraint given by is replaced by*

$$d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + (1-\tau_t^c)\frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 + T_t$$

3. *the government's budget constraint is*

$$T_t = \tau_t w_t h_t + \tau_t^c \frac{b_{t+1}}{1+r_t}$$

4. *the intratemporal labor Euler is replaced by*

$$\chi h_t^{\nu} = \frac{dc_t}{dc_t^T}(1-\tau_t)w_t$$

5. *the Euler equation for b_{t+1} is replaced by*

$$(1+\eta_t)\,(1-\tau_t^c) = (1+r_t)\beta\mathbb{E}_t m(S_t, S_{t+1})\,(1+\eta_{t+1}) + \mu_t$$

6. *perceived policies coincide with actual policies.*

Optimal Payroll Taxes

The normative analysis shows that bank-firms under-invest in the competitive equilibrium since they over-demand labor. In this section, I examine whether payroll taxes are useful to correct this inefficiency.

Definition 1.11 (**Optimal Time-Consistent Payroll Tax Policies**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self:*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta\mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t^h\right\}$ τ_t^h shows payroll taxes. This problem is subject to competitive equilibrium conditions (Equation A.1 - Equation A.21):

1. *the government's budget constraint is*

$$T_t = \tau_t^h w_t h_t$$

2. *the bank-firm's budget constraint is replaced by*

$$d_t = p_t^N y_t^N - (1-\tau_t^h) w_t h_t - p_v v_t + (1-\delta) k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + \frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 + T_t$$

3. *perceived policies coincide with actual policies.*

A.4 Competitive Equilibrium Conditions

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

$$\frac{dc_t}{dc_t^T} = \left[a\left(c_t^T\right)^{1-\frac{1}{\xi}} + (1-a)\left(c_t^N\right)^{1-\frac{1}{\xi})}\right]^{\frac{1}{1-\xi}} a\left(c_t^T\right)^{-\frac{1}{\xi}} \tag{A.2}$$

$$u_{1t} = \left(c_t - \chi\frac{h_t^{1+\nu}}{1+\nu}\right)^{-\sigma} \tag{A.3}$$

$$u_{2t} = -\left(c_t - \chi\frac{h_t^{1+\nu}}{1+\nu}\right)^{-\sigma}\chi h_t^{\nu} \tag{A.4}$$

$$\chi h_t^{\nu} = \frac{dc_t}{dc_t^T} w_t \tag{A.5}$$

$$\lambda_t = u_{1t}\frac{dc_t}{dc_t^T} \tag{A.6}$$

$$\lambda_t = 1 + \eta_t \tag{A.7}$$

$$m(S_t, S_{t+1}) = \frac{\lambda_{t+1}}{\lambda_t} \tag{A.8}$$

$$p_t^N = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{\frac{1}{\xi}} \tag{A.9}$$

$$y_t^N = z k_{jt}^{\alpha_k} v_{jt}^{\alpha_v} h_{jt}^{\alpha_h} \tag{A.10}$$

$$c_t^T + b_t + k_{t+1} = y_t^T + \frac{b_{t+1}}{1+r_t} + (1-\delta)k_t - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 \tag{A.11}$$

$$c_t^N = y_t^N \tag{A.12}$$

$$d_t = p_t^N y_t^N - w_t h_t + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + \frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 \tag{A.13}$$

$$(1+\eta_t) = (1+r_t)\beta\mathbb{E}_t\left\{m(S_t, S_{t+1})(1+\eta_{t+1})\right\} + \mu_t \tag{A.14}$$

$$(1+\eta_t)\left(1 + a_k\left(\frac{k_{t+1}}{k_t} - 1\right)\right) = \beta\mathbb{E}_t\left\{m(S_t, S_{t+1})\left[1 - \delta + \frac{a_k}{2}\left(\left(\frac{k_{t+2}}{k_{t+1}}\right)^2 - 1\right) + \frac{\alpha_k}{\alpha_h}\frac{w_{t+1}h_{t+1}}{k_{t+1}}\right]\right.$$
$$\left.(1+\eta_{t+1})\right\} + \kappa_t\mu_t \tag{A.15}$$

$$(1+\eta_t)\left((\gamma-1)p_t^N y_t^N(1+\tau_y) - w_t h_t\frac{\gamma}{\alpha_h} + a_p\left(\pi_t^N - \pi^N\right)\pi_t^N\right) = \mathbb{E}_t\left\{m(S_t, S_{t+1})\left(1+\eta_{t+1}\right)a_p\right.$$
$$\left.\left(\pi_{t+1}^N - \pi^N\right)\pi_{t+1}^N\right\}$$

(A.16)

$$\frac{\alpha_v}{\alpha_h}\frac{w_t h_t}{v_t} + p_v = \mu_t \theta p_v \tag{A.17}$$

$$\mu_t \left(\frac{b_{t+1}}{1+r_t} + \theta p_v v_t - \kappa_t k_{t+1} \right) = 0, \quad \mu_t \geq 0 \tag{A.18}$$

$$\eta_t \left(\underline{d} - d_t \right) = 0, \quad \eta_t \geq 0 \tag{A.19}$$

$$\epsilon_t = \frac{p_{t-1}^N}{p_t^N} \pi_t^N \tag{A.20}$$

$$i_t = k_{t+1} - (1-\delta)k_t + \frac{a_k}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t \tag{A.21}$$

A.5 Transition Matrix

I suppose that financial shock is exogenous to tradable endowment and interest rate, as generally assumed in the macro-finance literature. The transition matrix is then

$$\begin{bmatrix} 0.80 & 0.13 & 0.00 & 0.00 & 0.03 & 0.00 & 0.03 & 0.00 \\ 0.15 & 0.80 & 0.00 & 0.00 & 0.00 & 0.03 & 0.03 & 0.03 \\ 0.05 & 0.02 & 0.00 & 0.00 & 0.35 & 0.04 & 0.45 & 0.08 \\ 0.02 & 0.06 & 0.00 & 0.00 & 0.07 & 0.35 & 0.08 & 0.45 \\ 0.02 & 0.00 & 0.00 & 0.00 & 0.63 & 0.12 & 0.21 & 0.04 \\ 0.00 & 0.02 & 0.00 & 0.00 & 0.12 & 0.63 & 0.04 & 0.21 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.17 & 0.04 & 0.69 & 0.13 \\ 0.00 & 0.00 & 0.00 & 0.00 & 0.04 & 0.17 & 0.13 & 0.69 \end{bmatrix}$$

A.6 Figures

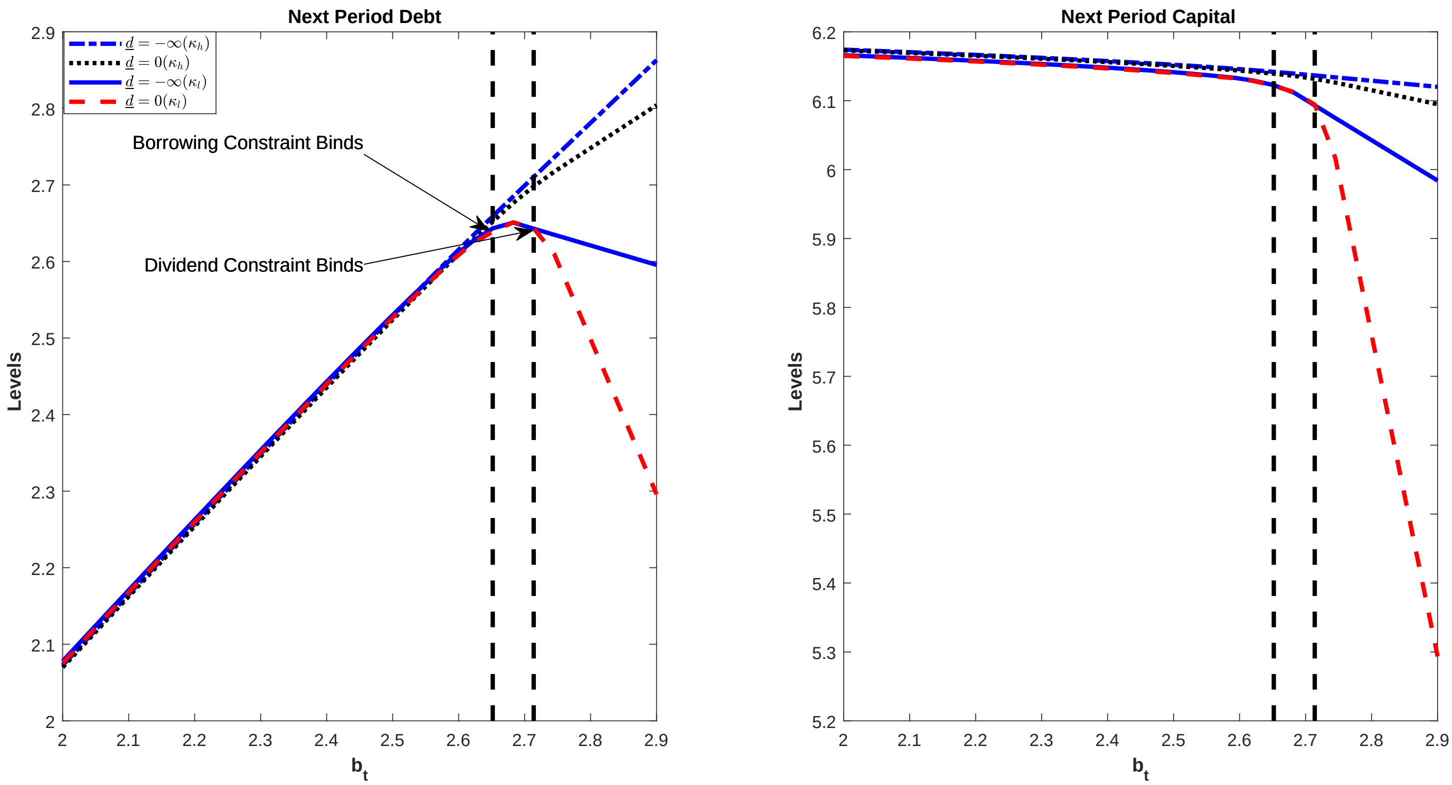

Figure 1.2: The dashed blue (black) line shows the policy functions without (with) domestic equity market constraints in the high borrowing regime. The solid blue and dashed red lines denote policy functions in the low borrowing regime.

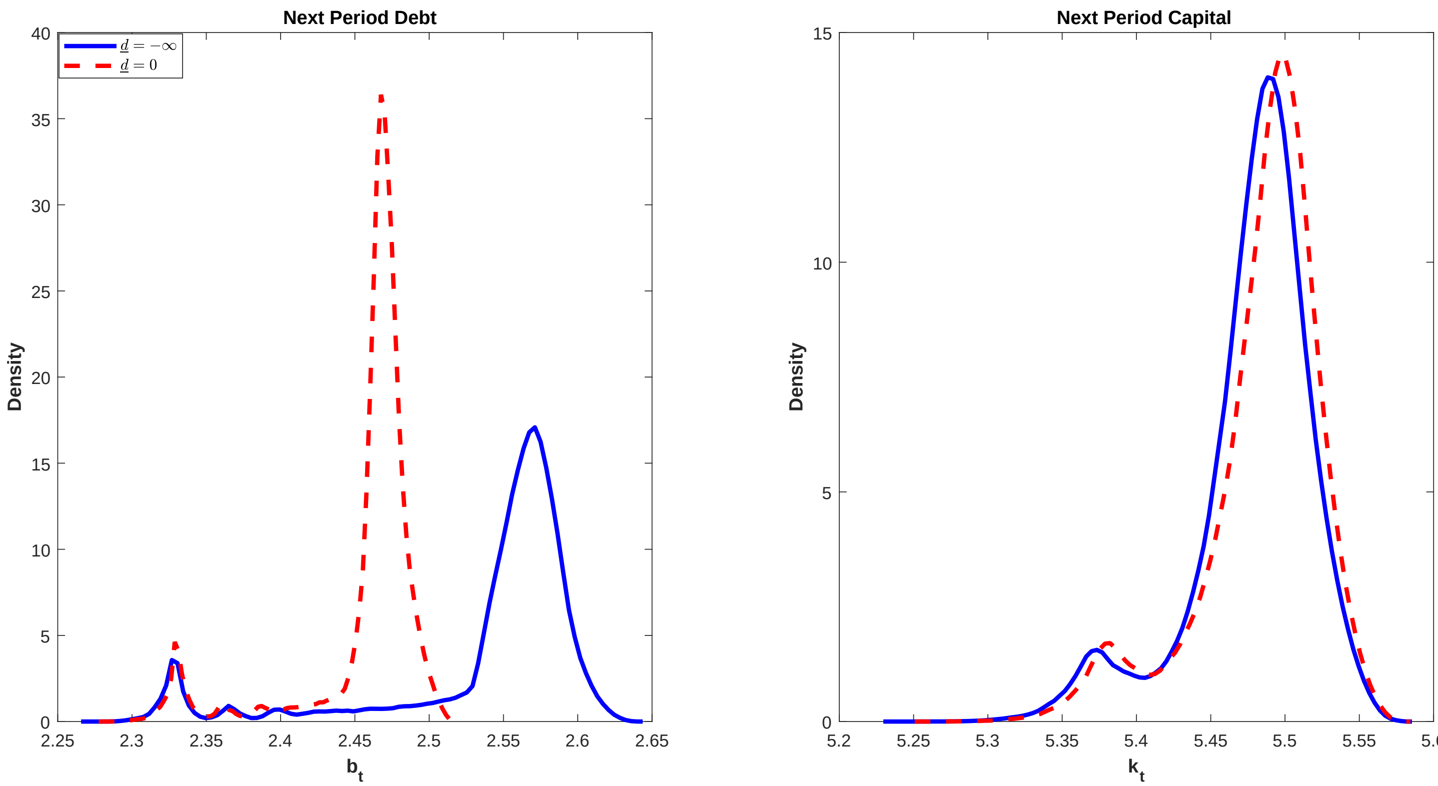

Figure 1.3: Limiting Distributions.

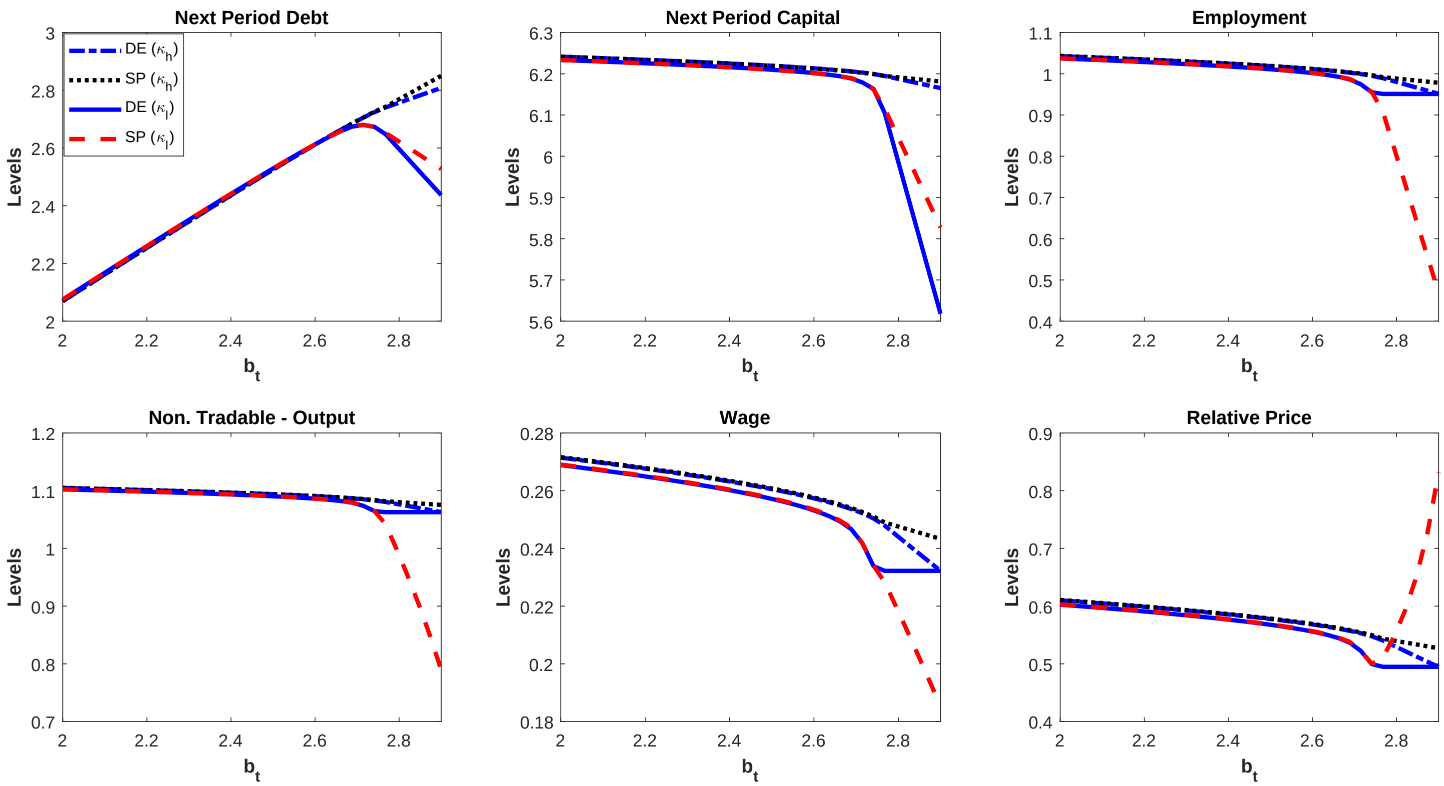

Figure 1.4: The dashed blue (black) line shows the policy functions of the decentralized equilibrium (social planner) in the high borrowing regime. The solid blue and dashed red lines denote policy functions in the low borrowing regime.

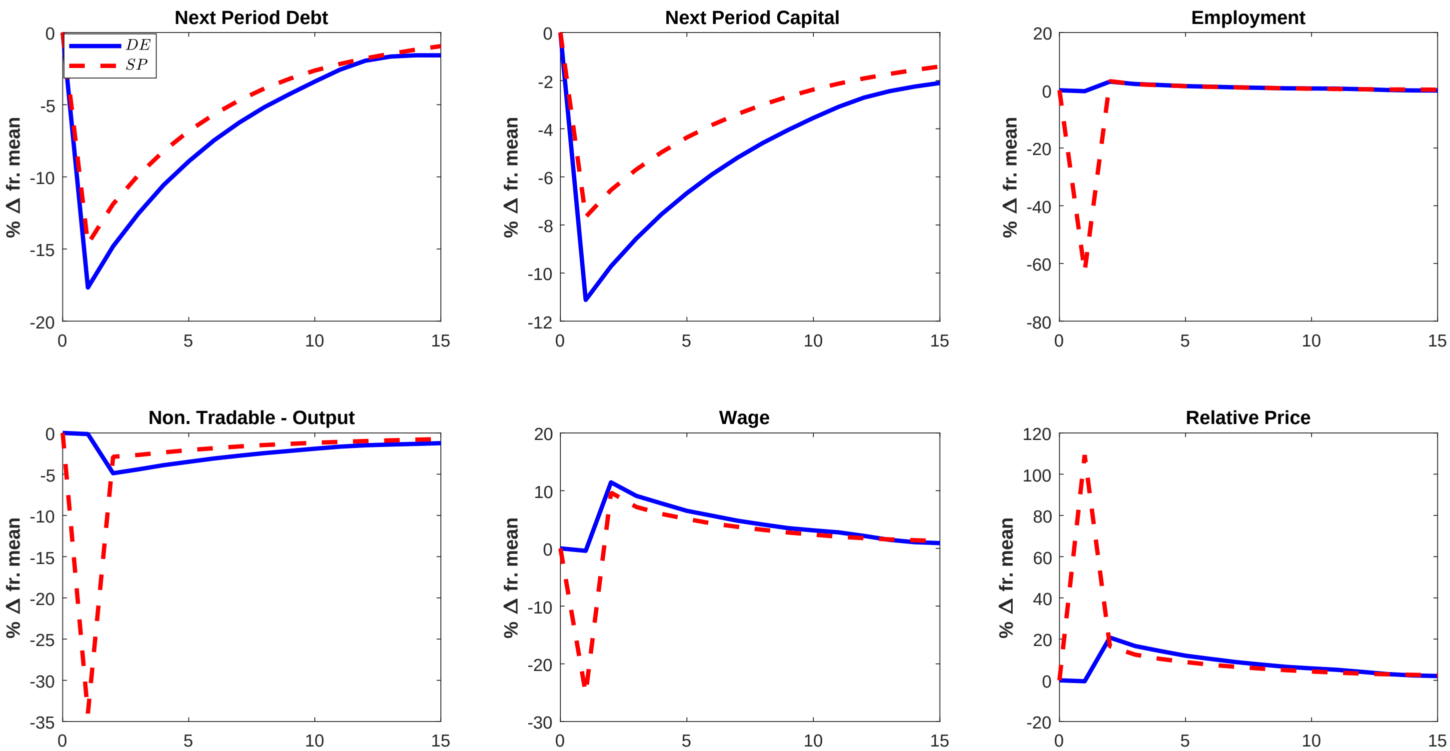

Figure 1.5: The solid (dashed) line shows the impulse response functions of the decentralized equilibrium (the social planner) to a negative financial shock.

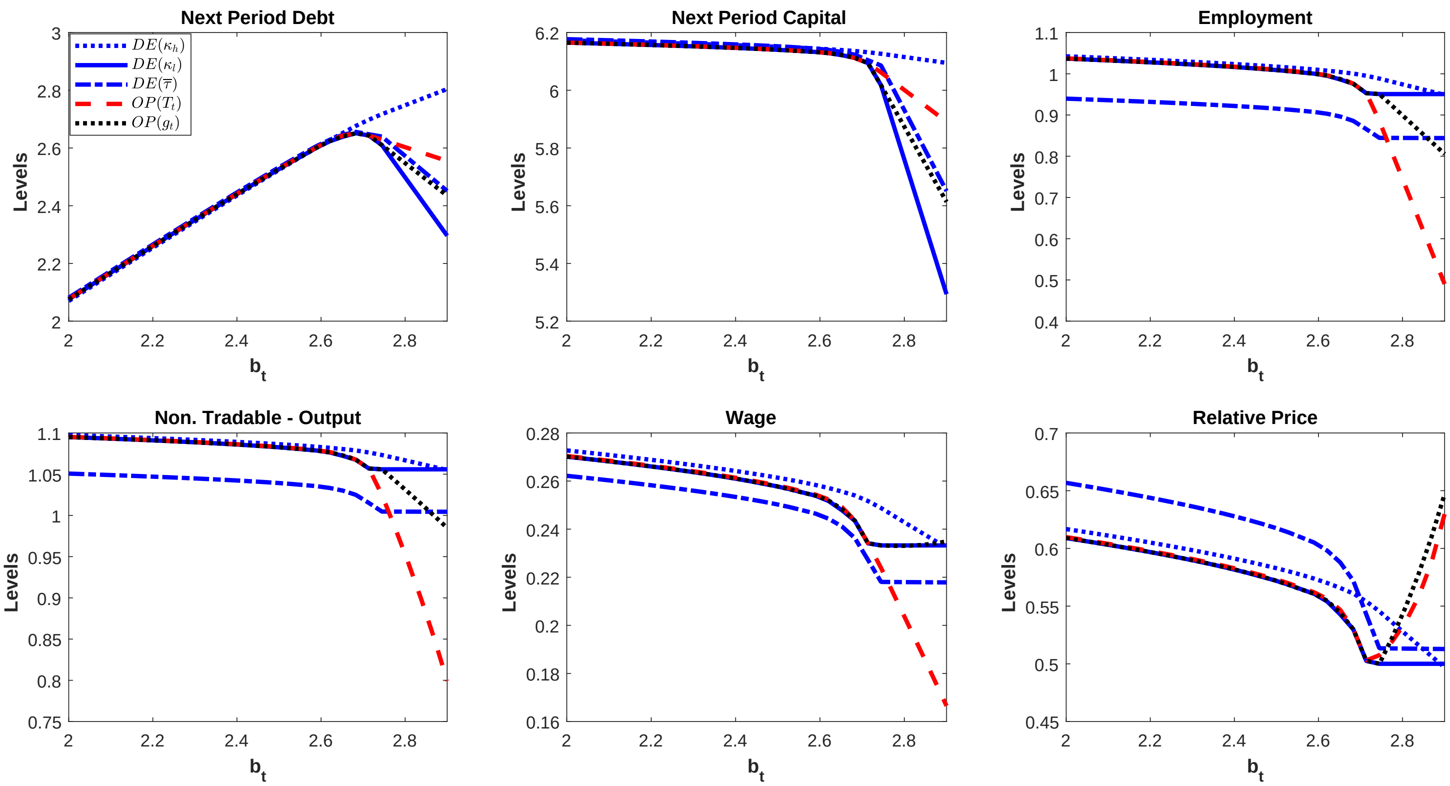

Figure 1.6: The dashed (solid) blue line shows the policy functions when constraints are slack (binding). The dashed red and black lines show the laws of motions with bailouts and capital control policies under the tight borrowing regime, respectively.

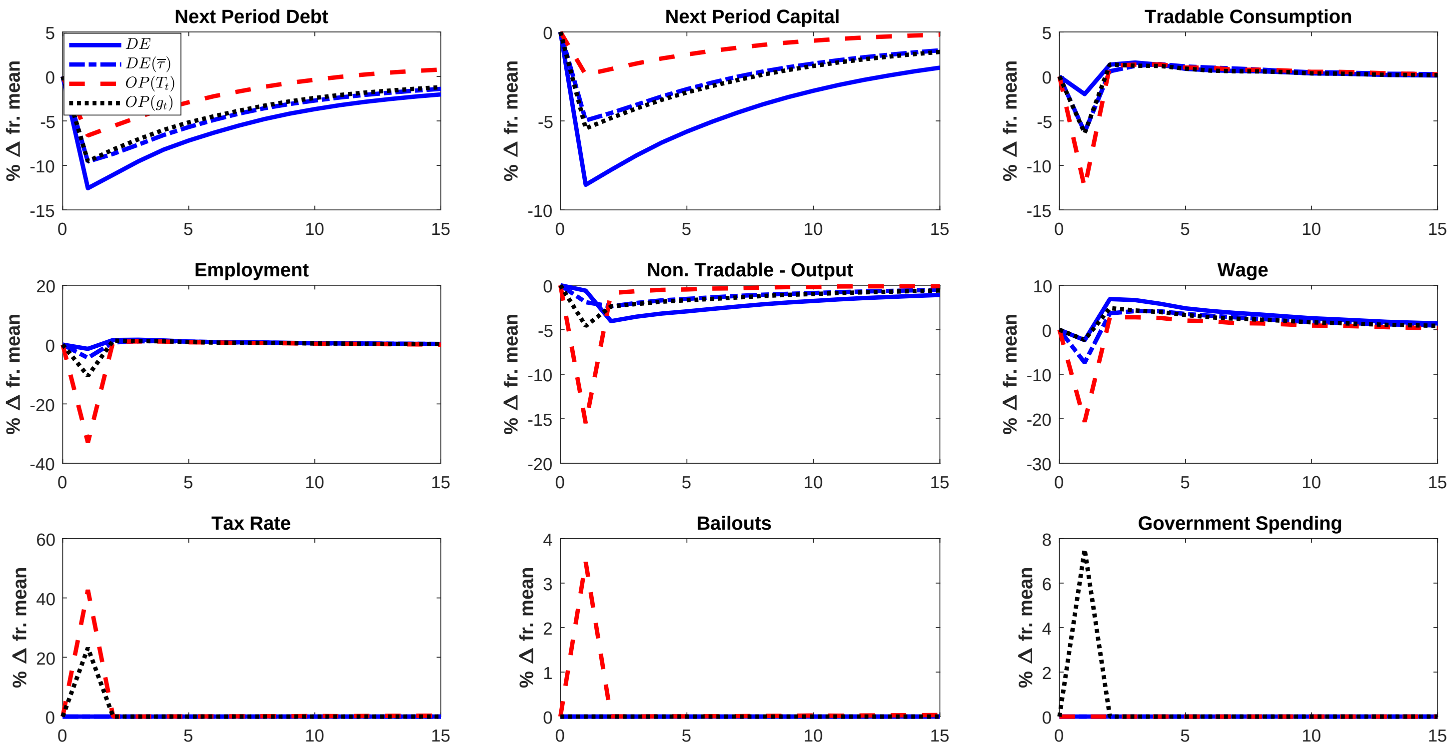

Figure 1.7: The solid (dashed) line shows the impulse response functions of the benchmark model (bailouts and price support models) to an adverse financial shock.

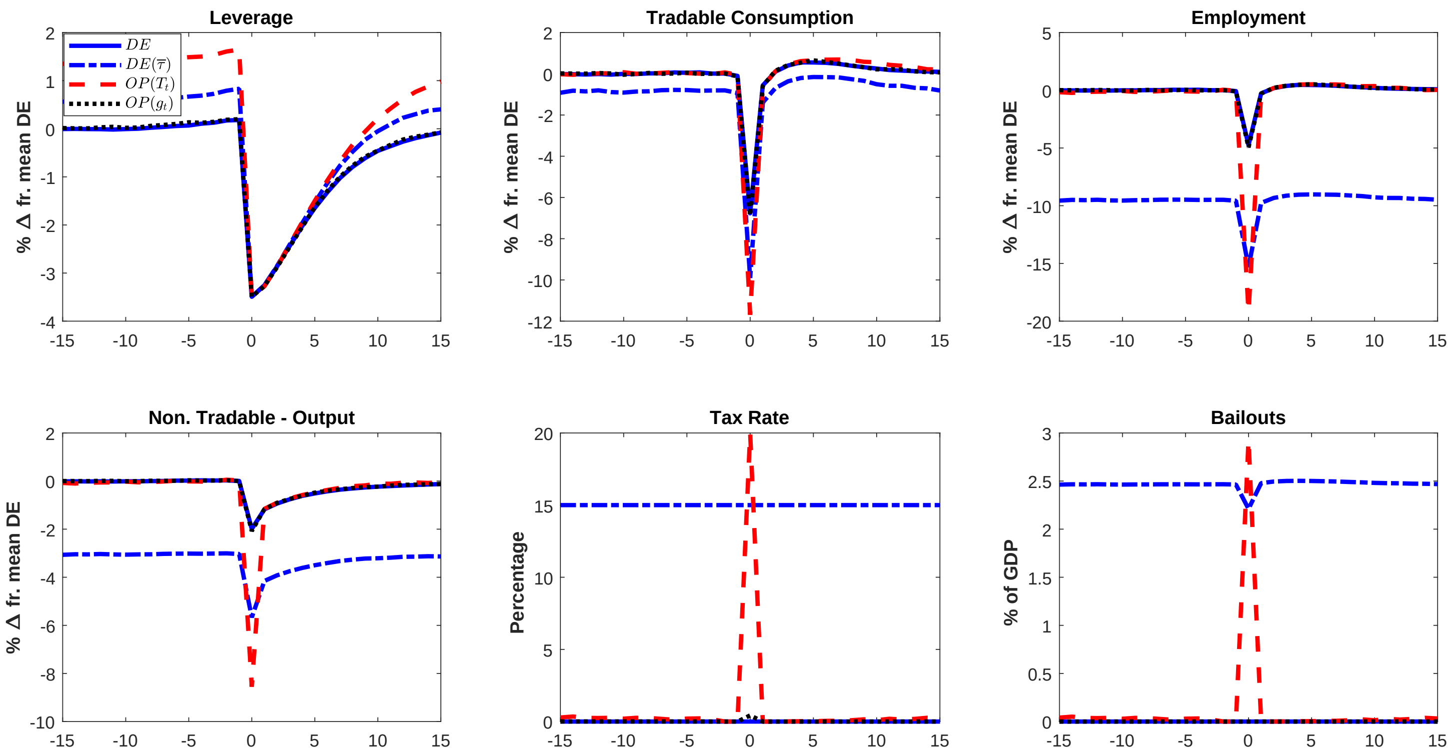

Figure 1.8: Event analysis.

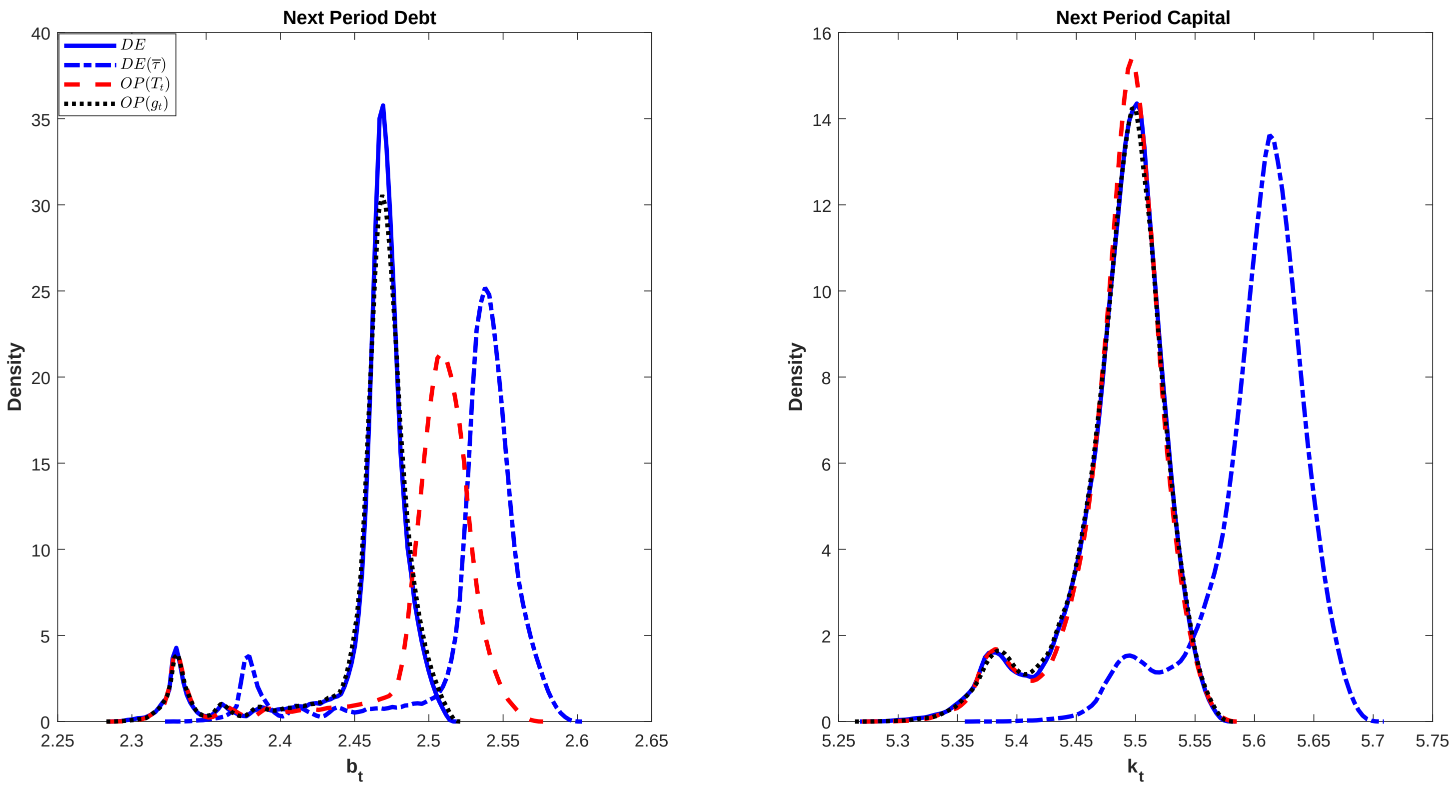

Figure 1.9: Limiting Distributions.

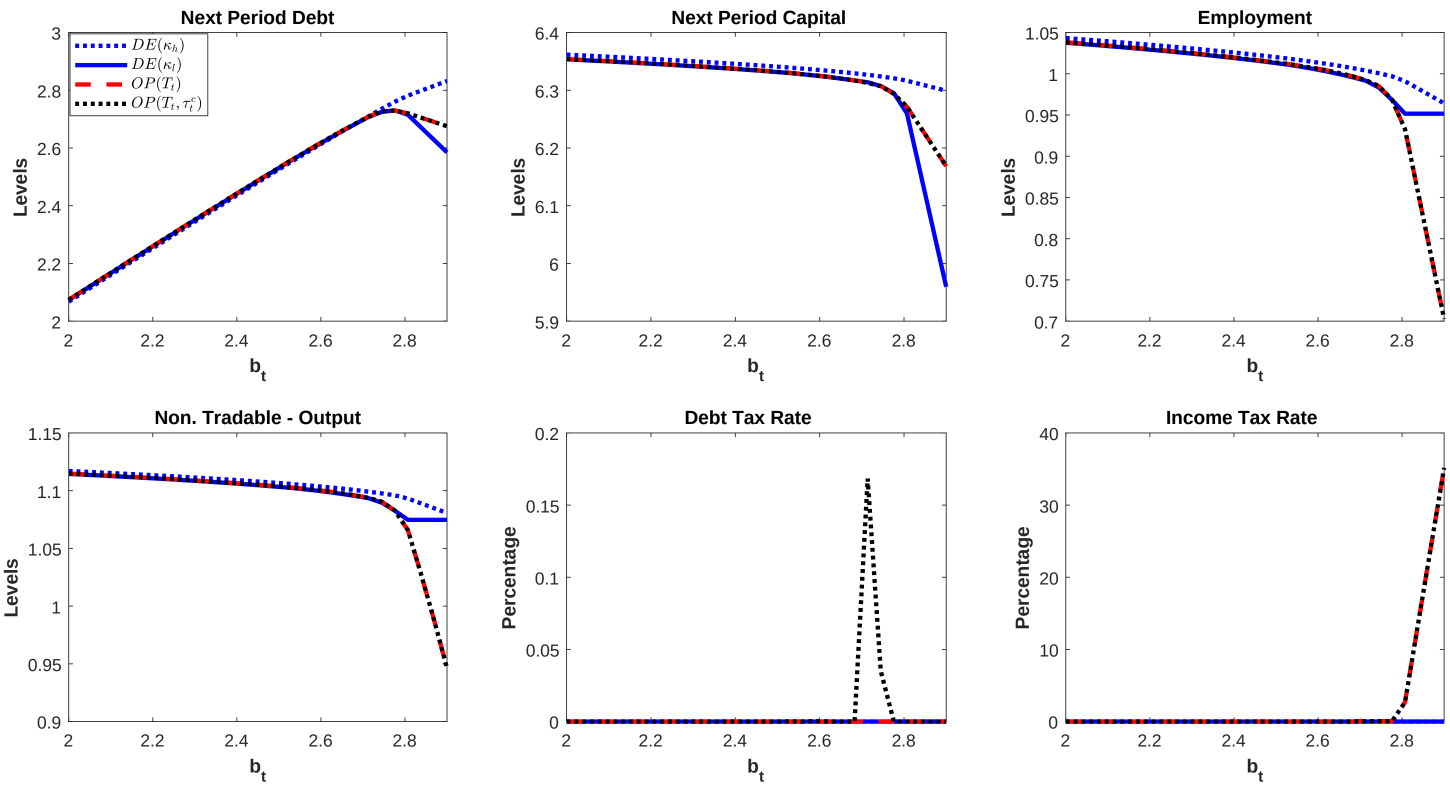

Figure 1.10: The dashed (solid) blue line shows the policy functions when constraints are slack (binding). The dashed red and black lines show the laws of motions with bailouts and capital control policies under the tight borrowing regime, respectively.

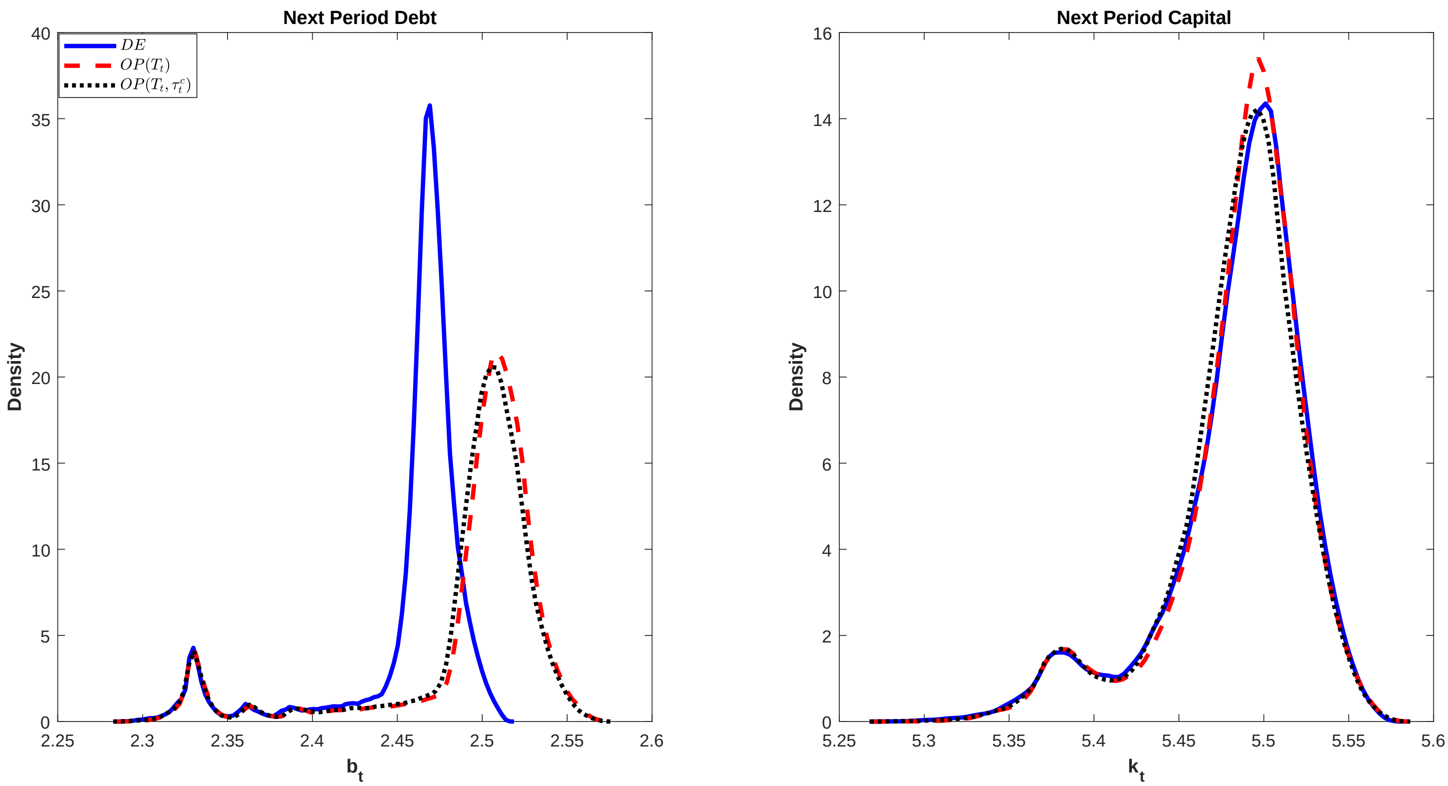

Figure 1.11: Limiting Distributions.

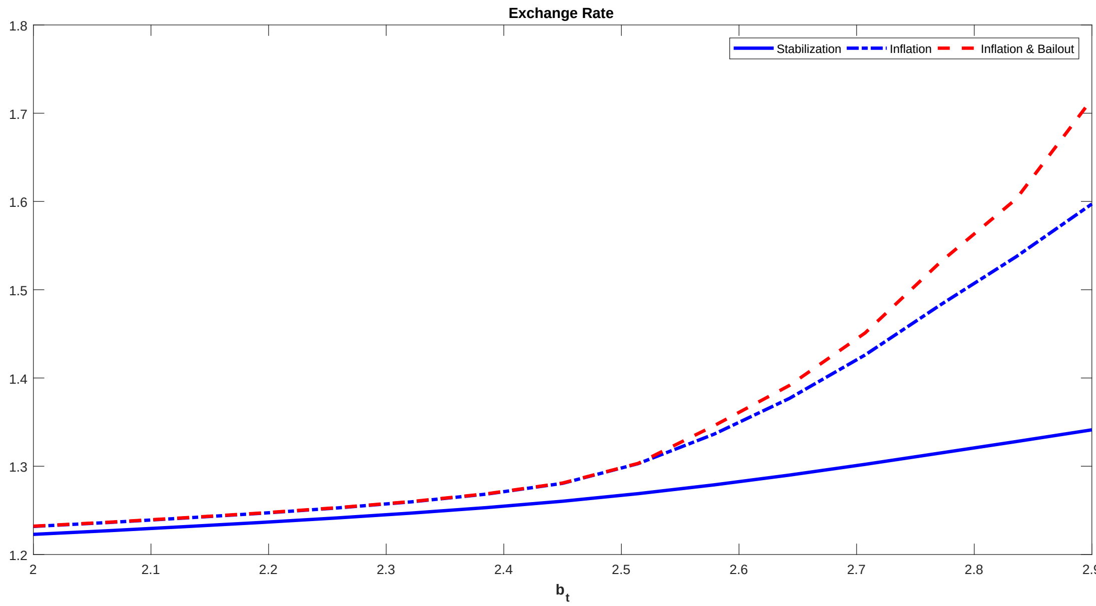

Figure 1.12: The figure shows the exchange rate under inflation stabilization policy (Stabilization), optimal inflation policy without bailouts (Inflation), and optimal inflation policy with optimal bailouts (Inflation & Bailout).

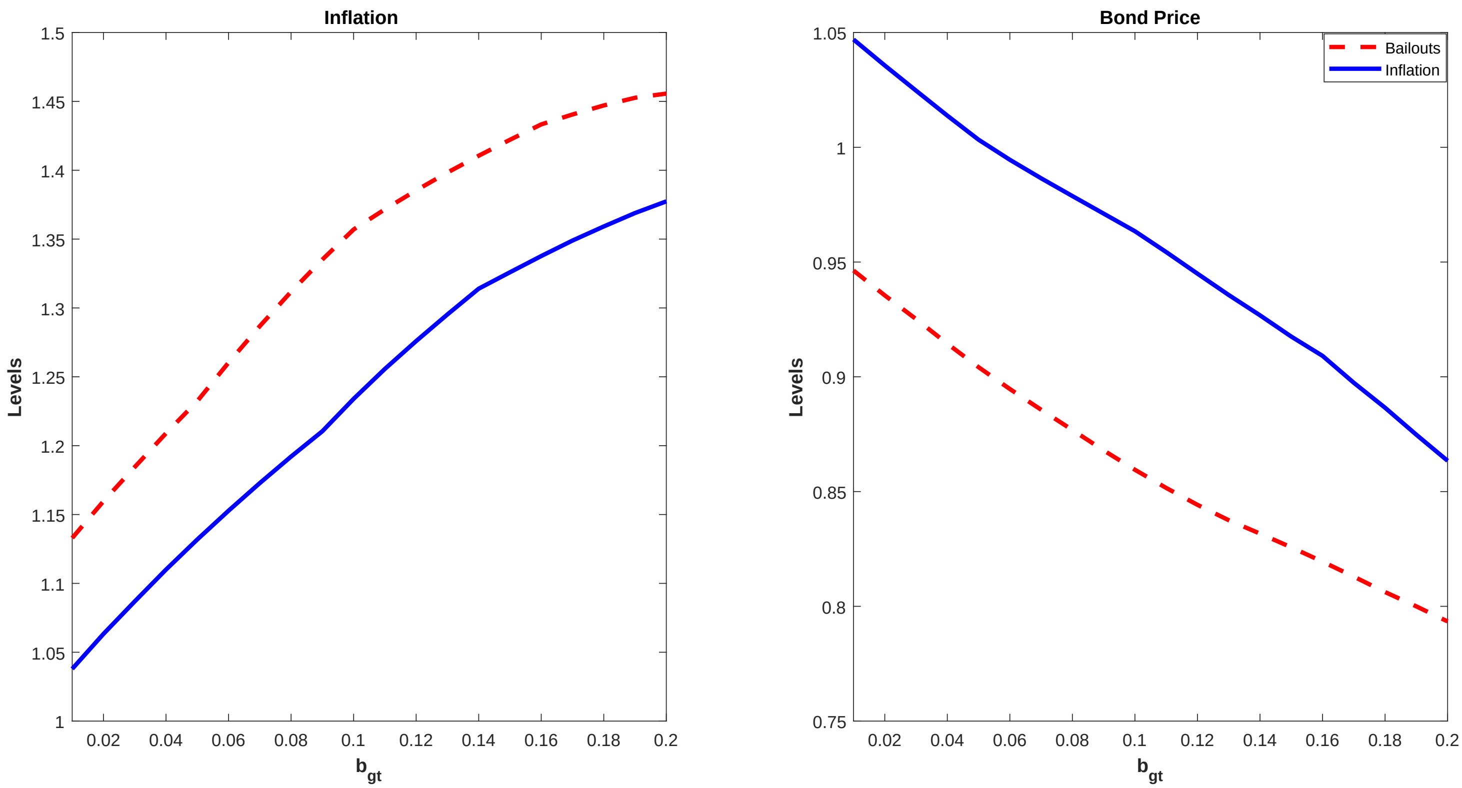

Figure 1.13: The figure shows inflation and the price of nominal debt under optimal inflation and bailout policies.

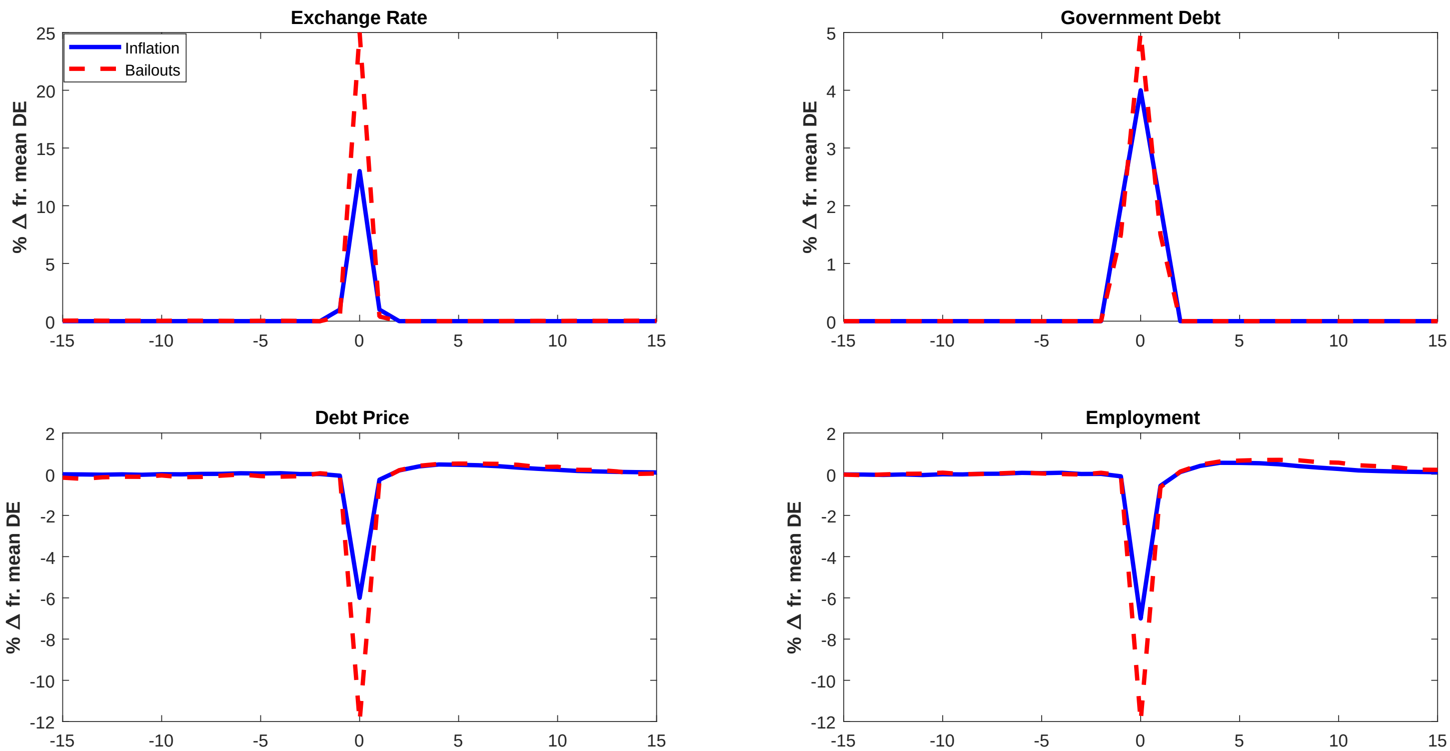

Figure 1.14: Event analysis.

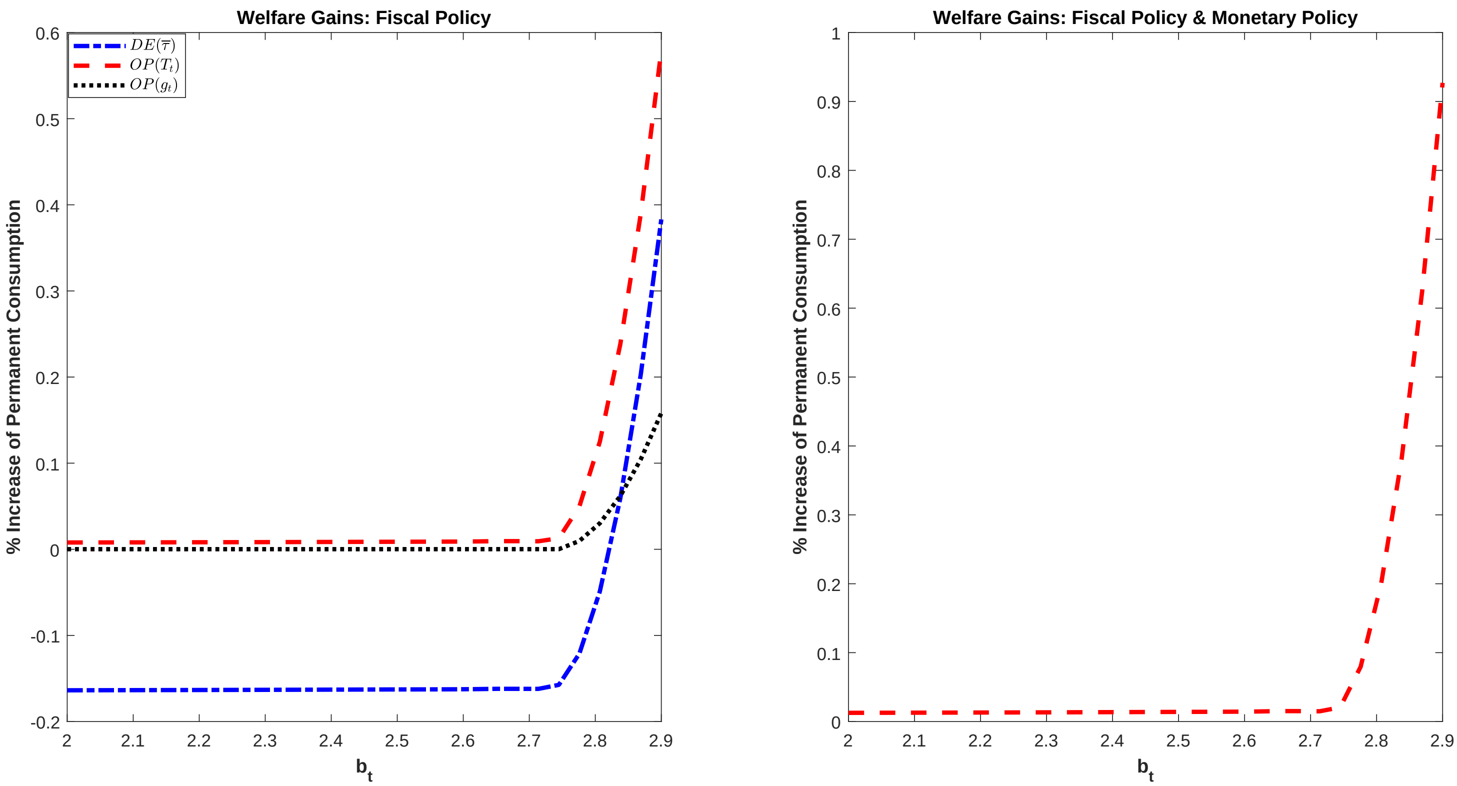

Figure 1.15: Welfare gains as a percent of aggregate consumption.

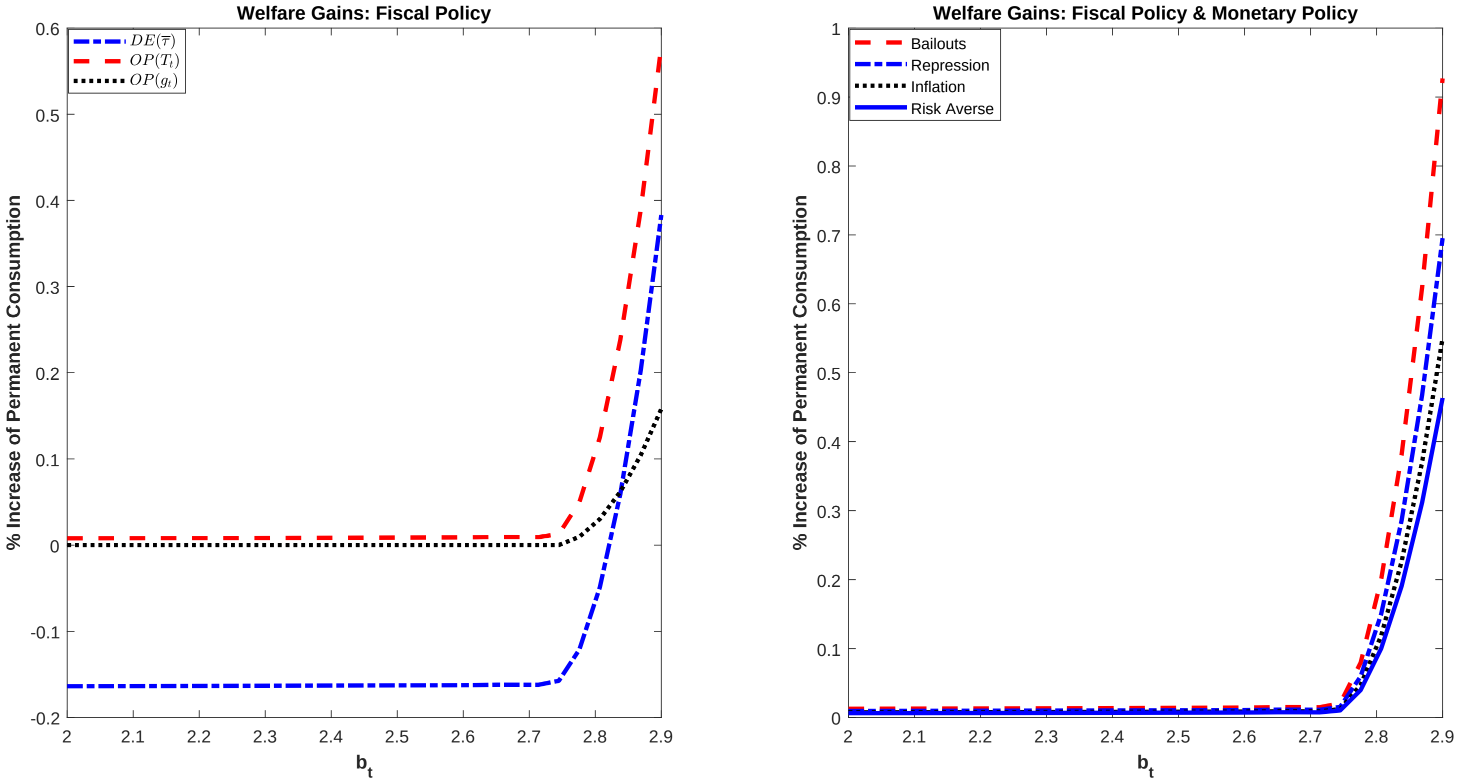

Figure 1.16: Welfare gains as a percent of aggregate consumption.

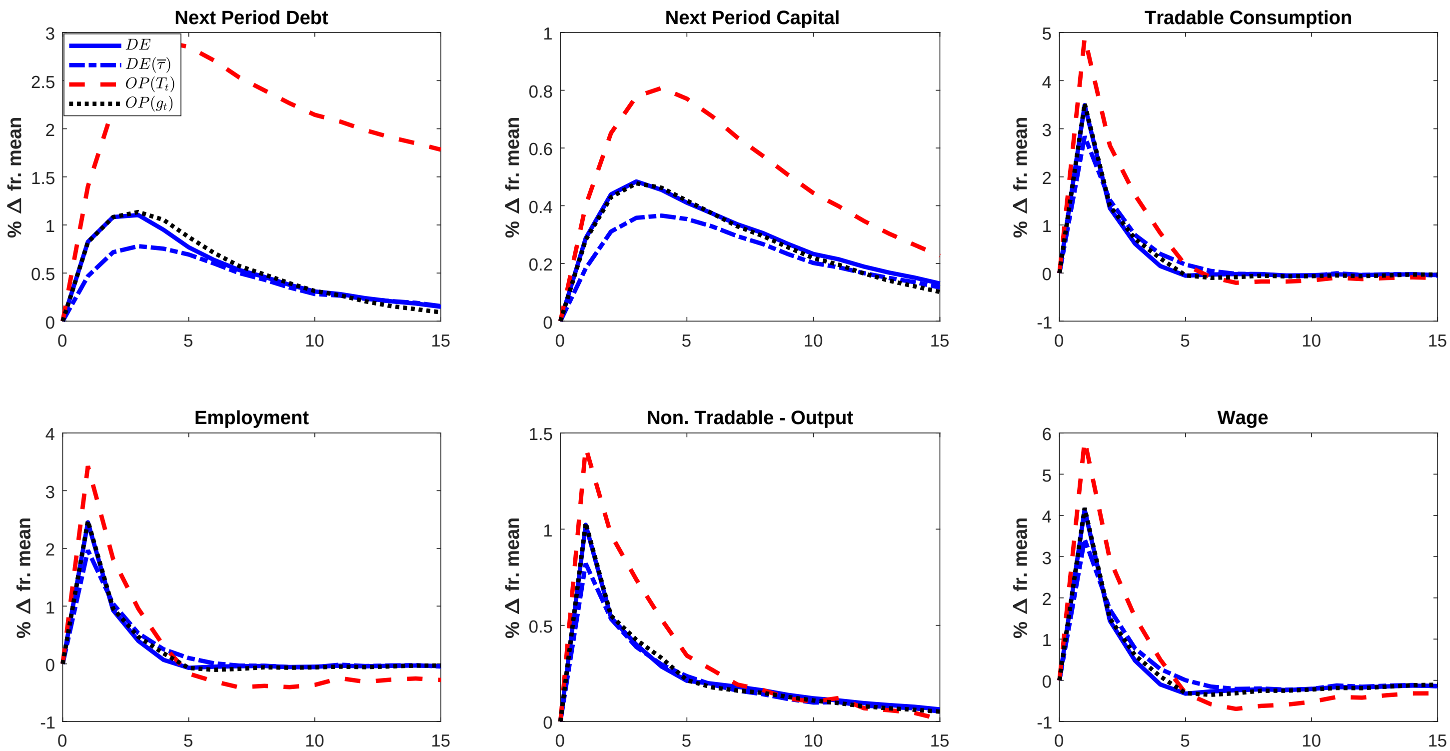

Figure 1.17: The solid (dashed) line shows the impulse response functions of the benchmark model (bailouts and price support models) to a positive tradable income shock.

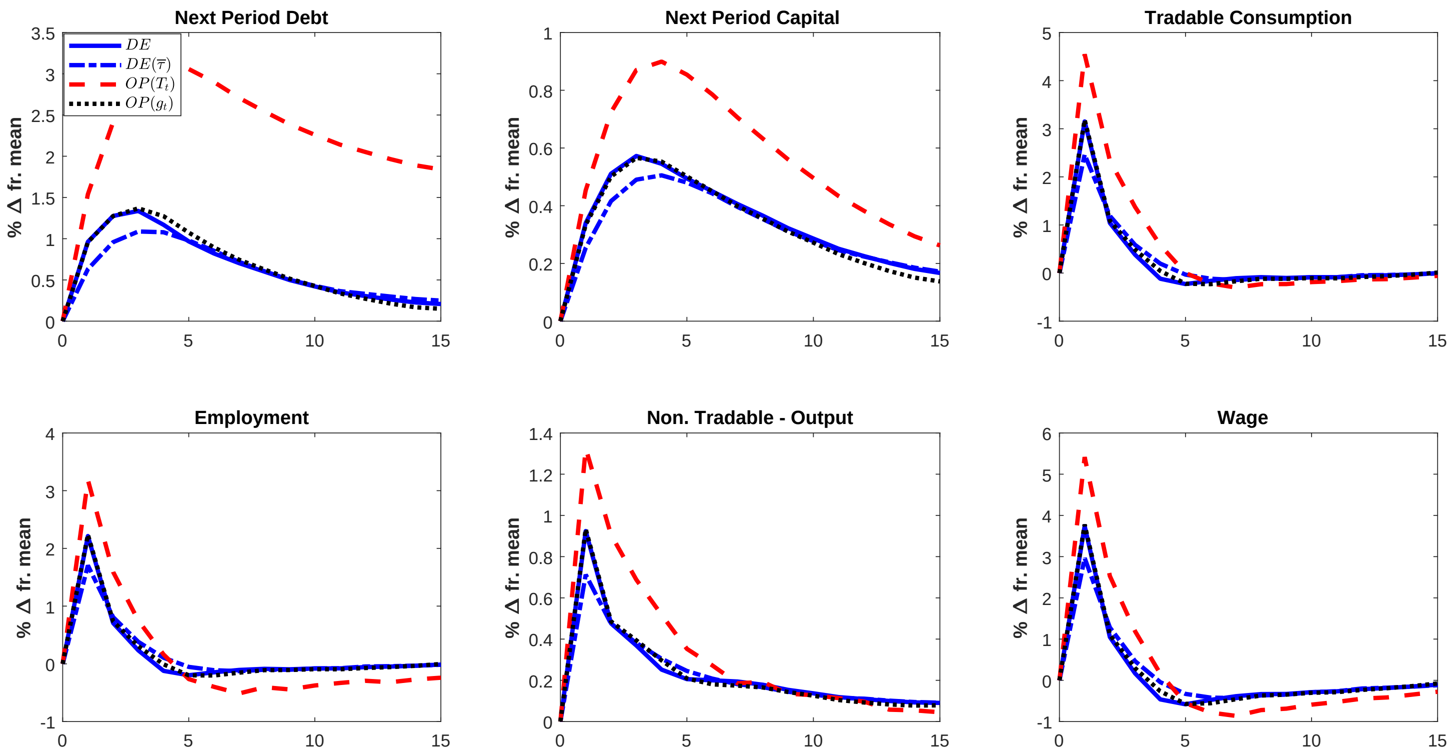

Figure 1.18: The solid (dashed) line shows the impulse response functions of the benchmark model (bailouts and price support models) to a negative interest rate shock.

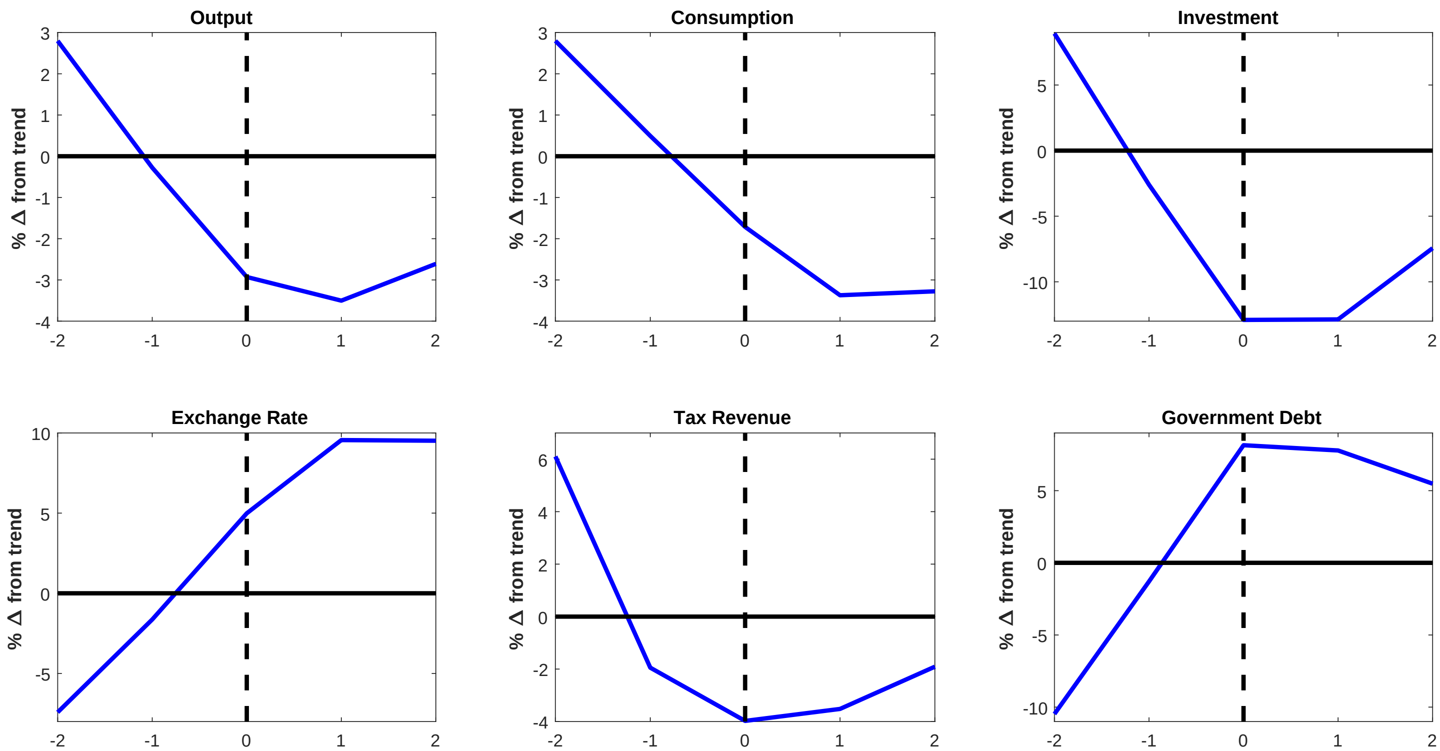

Figure 1.19: The crisis starts at period zero. The X-axis denotes the distance from a crisis, and Y-axis shows the percent deviation of a variable from its trend.

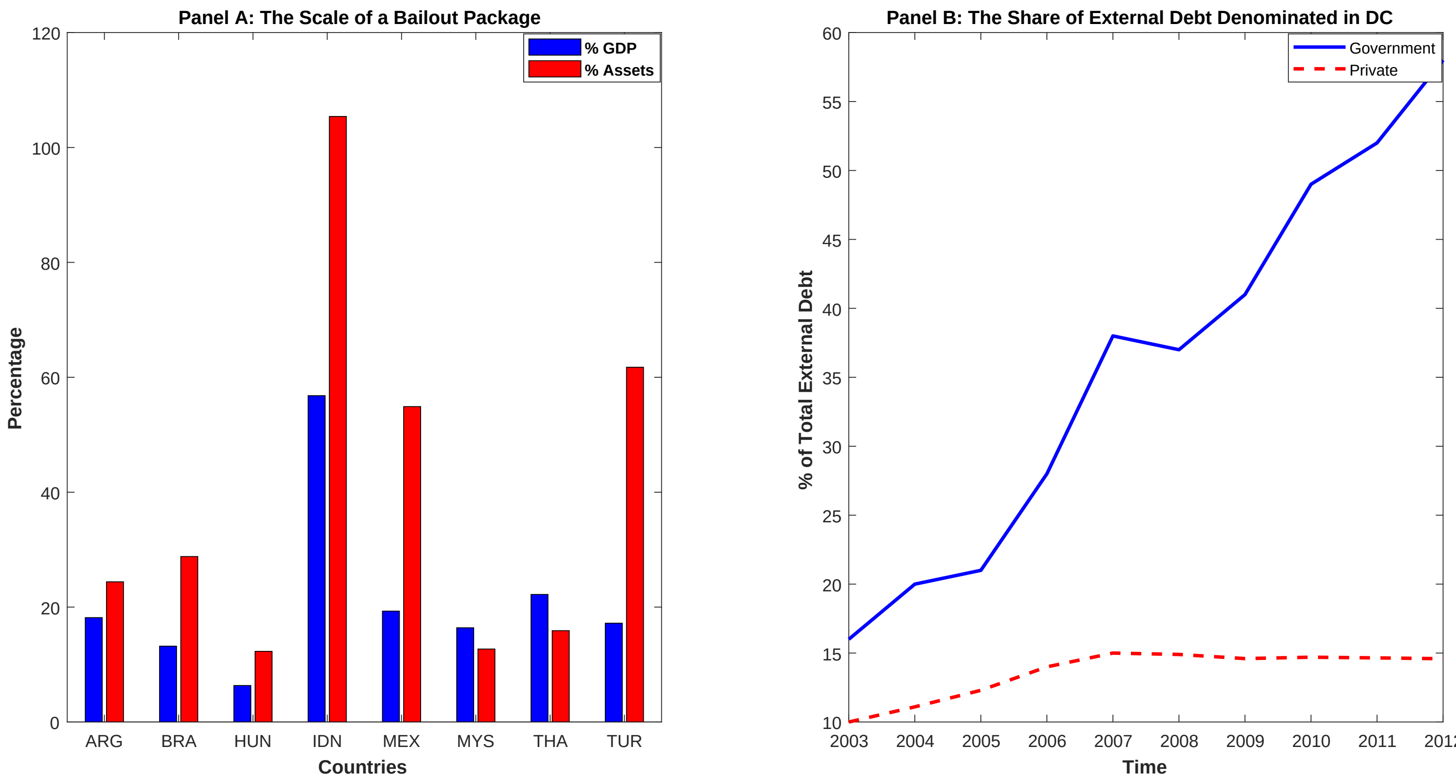

Figure 1.20: Panel - A shows the average scale of bailouts as a percent of GDP and financial assets. Panel - B plots the share of government and private sector debt as a percent of external debt.

A.7 Tables

$\rho(FC_{-1}, var)$	Depreciation	Inflation	Tax	Debt
Argentina	0.0308	0.2499	−0.8338	0.4215
Brazil	0.4877	0.4759	−0.9196	0.3489
China	0.5176	0.4941	−0.5474	−0.3944
India	0.4754	0.0945	−0.8357	0.4695
Indonesia	0.0869	0.2332	−0.9657	−0.1416
Malaysia	0.2583	0.1361	−0.6305	0.4187
Mexico	0.3993	0.8356	−0.9245	−0.0181
Philippines	0.3591	0.5223	−0.8937	0.5578
Russia	0.6703	0.6844	−0.8082	0.4756
Turkey	0.7011	0.8145	−0.9155	0.3685
Average	0.4016	0.5362	−0.7658	0.2992

Table 1.1: The table shows correlations between the lag of the FC liability and depreciation, inflation, tax revenue, government debt for some selected countries, and emerging market average. Depreciation (inflation) is the change in the nominal exchange rate (consumer price index) from the previous period to the current period.

	Bailout	Bailout	Bailout	Bailout
FC_{-1}	0.5447	0.5160	0.5314	0.4643
	(0.0060)	(0.0120)	(0.0052)	(0.0170)
$Exports_{-1}$		−0.0151	0.1177	0.5652
		(0.8280)	(0.1580)	(0.130)
$Reserves_{-1}$			−0.4309	−0.5367
			(0.0031)	(0.005)
Tax_{-1}				−0.1627
				(0.7220)
$Debt_{-1}$				−0.2511
				(0.3271)

Table 1.2: Regression results. P-values are reported within the parentheses.

Parameter	Description	Value	Target
σ	Risk Aversion	2.00	Standard
β	Discount Factor	0.96	K/Y
δ	Depreciation Rate	0.02	I/Y
α_k	Capital Share	0.33	Standard
α_v	Imports Share	0.15	Standard
α_h	Labor Share	0.50	Standard
χ	Labor Disutility	0.69	$\overline{h} = 1$
z	Output Scale	0.42	$y^N = 1$
θ	Working Capital	0.16	Bianchi and Mendoza (2018)
ν	Frisch Elasticity	0.50	Fr. Elas.
a	Share of Non-Trad.	0.42	c^N/c^T
ξ	Elas. Subs. Tra. and Non-tra.	0.44	Standard
ζ	Decay Rate	0.76	Avg. Dur.
$\underline{d}$	Equity Threshold	0.00	Standard
a_p	Price Adjustment Cost	0.40	Std. of π_t^N
a_k	Capital Adjustment Cost	9.00	Std. of i_t
r^*	Risk Free Rate	0.04	Standard
ϕ	Non-Tra. Share in Gov. Spen.	0.90	g^N/g
γ	Elasticity of Subs.	3.00	Standard

Table 1.3: Parameter Values

b	e	π^N	b_g	T	q	y
Full						
b	0.63	0.55	0.44	0.50	-0.39	0.78
Model - 1						
b	–	–	0.74	0.39	-0.48	0.65
Model - 2						
b	–	–	0.54	0.52	-0.53	0.69

Table 1.4: Correlations

Chapter 2

Optimal Recapitalization under the Presence of the Informal Economy

2.1 Introduction

Financial crises typically bring about a prolonged and deep decline in economic activity that inevitably forces governments in the developing world to conduct arbitrarily massive scale bailouts.[1] In particular, a bailout package in the developing world, on average, accounts for 12% of GDP (Valencia and Laeven, 2015), the cost that finally, at least partly, falls upon taxpayers. Besides, the average size of the informal economy is about 35% of GDP in the developing world (Schneider and Enste, 2000).[2] Motivated by these facts, I first ask whether governments in the developing world should recapitalize corporations, despite the costs. If so, what is the optimal way to finance the recapitalization under the presence of the informal

[1] A bailout package in the developing world typically consists of capital injections, asset purchases, and debt relief policies.

[2] Some recent empirical papers measure the size of the informal economy based on a large sample of countries (Elgin and Oztunali, 2012; Colombo, Onnis and Tirelli, 2016; Medina and Schneider, 2018). These studies also document that the size of the informal economy is significantly large in the developing world.

economy? This paper proposes that the policymaker should be more inclined to impose an inflation tax rather than income taxes on taxpayers as the size of the informal economy grows to finance the recapitalization.

The effectiveness of these arbitrarily large scale government interventions in accelerating the recovery from a crisis as well as the effects of anticipated interventions on ex-ante risk-taking has become the central element of the recent policy debate. The recapitalization of corporations, on the one hand, moderate the collapse in economic activity by relaxing the balance sheets of corporations, thereby accelerating capital formation in a crisis (Bianchi, 2016). On the other hand, anticipated interventions generate excessive leverage in pre-crisis that calling for ex-ante regulations to eliminate bailouts (Farhi and Tirole, 2012). Besides, the large scale recapitalization of corporations may also undermine the fiscal capacity of a government as consistent with empirical findings (Reinhart and Rogoff, 2011) that may, in turn, feedback into the private sector (Acharya, Drechsler and Schnabl, 2016; Farhi and Tirole, 2017). Also, the high share of the informal economy puts further pressure on the government's balance sheet in the urgent need of massive resources to recapitalize corporations as agents working in the informal economy substantially avoid income taxes.

In line with this perspective, this paper revisits the view arguing that fiscal policy alone is unable to accelerate the recapitalization adequately in a crisis. Consequently, I study whether an inflation tax, the classical monetary policy instrument that taxes informal economic activities indirectly, supplanted with income taxes is effective in promoting ex-post financial stability. Since governments in the developing world can not predominantly rely on tax revenues as tax evasion is substantial in the informal sector, the paper proposes that the recapitalization of corporations, at least partly, should be monetized.

To study the optimal finance of the recapitalization of the formal production sector under the presence of the informal production sector, the paper proposes a dynamic stochastic general equilibrium model with a tradable sector endowment and a non-tradable production sector akin to Bianchi (2016); Ergene (2019). In particular, non-tradable goods can be produced both in the formal and informal sectors. The official production sector is under the investigation of authorities, but the earnings from the unofficial production can not be detected.

Corporations that produce non-tradable goods under nominal and financial frictions in the formal sector have access to a one-period external debt instrument denominated in foreign currency together with domestic equity finances. Since their incomes denominated in domestic currency, unlike their debt, corporations suffer from the currency mismatch effect. This classical argument predicts that a faster domestic currency depreciation than prices rise increases the liability burden, thereby further tightening the balance sheets of corporations in a tight credit regime in line with the "liability dollarization" argument (Krugman, 1999; Eichengreen, Hausmann and Panizza, 2003) and the "fear of floating" concept (Calvo and Reinhart, 2002). Consequently, this literature predicts a smaller devaluation when the private sector highly exposed to foreign currency debt, and that conclusion challenged under the presence of the informal economy.

In this framework, a crisis occurs when the external borrowing and domestic equity market constraints bind. In particular, tight credit constraints prevent corporations from financing the desired level of investment, thereby resulting in a massive fall in output and employment. The binding domestic equity market constraint, together with the tight external borrowing constraint, leads to a sharper slump in investment since corporations otherwise would fund investment opportunities by acquiring new resources from shareholders. Households can not recognize that the future benefits of transferring resources to corporations in tight financial regimes outweigh contemporaneous costs. This inefficiency generates scope for government intervention. In particular, the benevolent domestic policymaker can extract resources from households through costly fiscal and monetary policy instruments to accelerate the recovery from a crisis by transferring these resources to corporations' balance sheets.

The policymaker can impose income taxes on households working in the formal production sector, but the agents operating the unofficial labor-intensive production technology can avoid income taxes at no cost (Koreshkova, 2006; Amaral and Quintin, 2006). Households acquire consumption goods using cash or credit. Costly credit assures some transactions made using cash and generates money demand together with the cash-in-advance constraint (Ireland, 1994). The policymaker balances the tax burden between income taxes in the formal sector and an inflation tax on money holdings in both the formal and informal sectors.

The policymaker chooses the optimal time-consistent scale of the recapitalization of corporations financed through income taxes and an inflation tax. I find the optimal time-consistent policies that maximize the welfare of the domestic representative agent by value function iteration, and the competitive equilibrium allocations by the Euler equation method based on the policy function iteration. Then, I compare the crisis episode of an average developing world economy with the dynamics of a crisis in the model by calibrating the model accordingly. Since the Ramsey policies suffer from the time-inconsistency, I focus on the time-consistent optimal policies. In particular, while government interventions alleviate the under-capitalization of corporations in a crisis, they must be limited to mitigate ex-ante moral hazard effects. However, an ex-ante promise to eliminate ex-post government interventions is not credible, since the policymaker finds it optimal to recapitalize corporations when an adverse financial shock tightens the constraints.

In the quantitative analysis, I first consider the case in which the policymaker not permitted to recapitalize corporations in a crisis to show the relative effectiveness of interventions but still issues money, collects income taxes, and chooses an inflation tax. The policymaker rebates government revenue as lump-sum transfers to households. In that case, it is optimal to conduct a smaller devaluation due to the currency mismatch effects in line with the classical arguments. In particular, following an inflationary policy under price stickiness increases the liability burden as the domestic currency depreciates faster than prices rise as well as distorts labor demand and raises menu costs without any benefits. Unlike Koreshkova (2006) abstracting from these endogenous costs of inflationary policies, the optimal devaluation policy still embraces the "fear of floating" argument without interventions even under the presence of the informal economy. Simply because allowing a smaller devaluation in a crisis limits the arbitrary increase in the external debt burden, thereby helping to accelerate capital formation. However, this policy increases the share of the informal economy that limits the recovery from a crisis as employment shifts from the formal sector to the informal sector. Besides, following a more conservative inflationary policy reduces the tax burden on transactions made using cash, thereby reducing the share of goods acquired using credit.

When the policymaker, however, allowed to recapitalize corporations to relax their tight constraints, the benefits of a higher devaluation outweigh the costs for two reasons. First, devaluation shifts the tax weight from income taxes to an inflation tax on transactions made using cash in the informal sector, thereby generating more seigniorage revenue. Second, the declining tax burden in the income tax alleviates the drop in employment that further helps to accelerate capital formation in the official production sector. Households increase the share of transactions made using credit as a response that limits the rise in government revenue. The quantitative analysis reveals that it is optimal to allow a higher devaluation as the size of the informal economy grows. Besides, this policy significantly raises welfare gains in contrast with the predictions of the classical currency mismatch argument. Thus, this paper proposes that the policymaker should monetize government interventions under the presence of the informal economy.

Similar to direct capital injections, expansionary fiscal policies supporting the relative price of non-tradable goods may also relax the tightness of financial constraints. In particular, the policymaker can increase government spending on non-tradable goods. This policy raises the relative price of non-tradable goods as demand expands for these goods. However, the quantitative analysis shows that the benefits of growing government spending can not outweigh the costs of it. In other words, the price support policy is not effective in recovering from a crisis.

Besides, anticipated interventions discourage corporations from the private provision for a crisis. In other words, corporations build-up excessive leverage in pre-crisis that eventually leads to a worse crisis. Then, I study whether the policymaker should conduct capital inflow taxes at regular times. Unlike Bianchi and Mendoza (2018) supporting capital controls to sustain collateral value based on the current asset prices, I find that capital inflow taxes are not optimal outside of a crisis.

Layout. Section 2.2 introduces the model economy. Section 2.3 describes time-consistent optimal policies. Section 2.4 explains solution methods, calibration strategies, and shows the main results. Section 2.5 shows welfare gains corresponding to each policy. Section 2.6 concludes.

2.2 Model

The model economy populated by households, corporations, and a benevolent domestic policymaker. Households supply labor to corporations and operate the production technology in the informal sector. Corporations make dividend payments to households, issue bonds denominated in FC at world markets, and invest in physical capital. The policymaker chooses money supply, government expenditures, and inflation as well as collects income taxes from households working in the formal production sector. Besides, the policymaker may recapitalize corporations to mitigate the under-capitalization of the formal production sector as well as limit external borrowing in this sector to moderate ex-ante excessive risk-taking.

I suppose that the assets market opens before the goods market (Cooley and Hansen, 1989). In particular, households first learn government policies and shocks in the current period. Second, the asset market opens, and households receive money transfers from the government. Third, households supply labor to corporations and operate the production technology in the informal sector. Fourth, the goods market opens, and households acquire goods using cash or credit. Fifth, households receive dividend payments and wage from corporations, and incomes from the informal production.

2.2.1 Households

There exists a continuum of identical households of unity mass. Households consist of workers and shoppers. Workers choose the time allocation among leisure and work, and shoppers' problem is to determine the share of transactions made using credit.[3]

Following Ireland (1994), I suppose that using credit is costly to ensure that some transactions made using cash.[4] The credit cost technology is given as:

$$\Gamma(z_t) = \int_0^{z_t} \frac{x}{1-x} dx$$

where $z_t \in [0, 1)$ shows the share of transactions made using credit. I suppose that there is no difference within credit technologies in each sector because of the lack of evidence of the cash concentration of transactions in the formal economy compared to the informal economy.[5]

[3] The model with a constant share of transactions made using credit would also produce similar results, but there is no concrete evidence of the portion of transactions made using credit. Thus, there is no direct counterpart of this parameter in the data.

[4] See also Dotsey and Ireland (1996); Koreshkova (2006) for a similar credit cost function.

[5] Even if I supposed that credit technologies are different in each sector, the model results would still carry through as long as some transactions made using cash.

The lifetime preferences of the representative household are

$$\max_{c_t^T, c_t^N, h_t^F, h_t^I, m_t^d, z_t} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t^{\nu} l_t^{1-\nu}\right)^{1-\sigma}}{1-\sigma} \tag{2.2.1}$$

where $\mathbb{E}$ is the expectations operator, β shows the subjective discount factor, σ denotes the constant relative risk aversion, c_t shows consumption, ν captures the share of consumption in the utility function, and l_t shows leisure. Time endowment normalized to unity. Then, l_t expressed as:

$$l_t = 1 - h_t^F - h_t^I \tag{2.2.2}$$

where h_t^F (h_t^I) is the labor supply in the formal (informal) sector. c_t is a CES index of tradable c_t^T and non-tradable c_t^N goods in the following form:

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

ξ is the elasticity of substitution between tradable and non-tradable goods.

Households receive stochastic tradable endowments y_t^T each period. 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:

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

where z^I is a scale parameter. The unofficial production technology exhibits decreasing returns to scale such that $\alpha_h^I < 1$ (Koreshkova, 2006).

Households are the shareholders of corporations and receive dividend payments d_t and nominal wages W_t. They start the current period with nominal money holdings M_{t-1}^d and receive lump-sum real money transfers T_t^m from the government. Households working in the formal sector pays income taxes τ_t to the government, but the earnings from the production in the informal sector concealed from the detection of authorities at no cost. Credit services cost $\Gamma(z_t)$ in terms of non-tradable goods.[6] The representative agent's budget constraint in nominal terms is

$$P_t^T c_t^T + P_t^N c_t^N + M_t^d + P_t^N \Gamma(z_t) = P_t^T y_t^T + (1-\tau_t) W_t h_t^F + P_t^T d_t + M_{t-1}^d + P_t^T T_t^m + P_t^N f(h_t^I)$$

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:

$$P_t^T = P_t^{T^*} e_t = e_t$$

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

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

The budget constraint in terms of the price of tradable goods is

$$c_t^T + p_t^N c_t^N + m_t^d + p_t^N \Gamma(z_t) = y_t^T + (1-\tau_t) w_t h_t^F + d_t + \frac{m_{t-1}^d}{\epsilon_t} + T_t^m + p_t^N f(h_t^I) \quad (2.2.3)$$

where $p_t^N = \frac{P_t^N}{P_t^T}$, $w_t = \frac{W_t}{P_t^T}$ and $m_t^d = \frac{M_t^d}{P_t^T}$ denote the relative price of non-tradable goods, wages, and real money demand in terms of tradable goods. $(1-z_t)$ fraction of the transactions made using cash. Thus, the cash-in-advance constraint is

$$(1-z_t)\left(c_t^T + p_t^N c_t^N\right) \leq \frac{m_{t-1}^d}{\epsilon_t} + T_t^m \quad (2.2.4)$$

This constraint is binding for the standard parameter values in this framework.[7]

The representative household maximizes the lifetime utility (Equation 2.2.1) subject to

[6] Credit costs could also be defined in terms of tradable goods, and the model would produce similar results as long as some fraction of transactions made using cash.

[7] Cooley and Hansen (1989) show that the sufficient condition for this constraint to bind with logarithmic utility is that money growth exceeds the discount factor. In this setup, the sufficient condition is that $\frac{1}{\beta} E_t \left\{ \frac{u_{2t}}{u_{2t+1}} \frac{p_{t+1}^N f'\left(h_{t+1}^I\right)}{p_t^N f'\left(h_t^I\right)} \epsilon_{t+1} \right\} > 1$. u_{2t} denotes the marginal utility of leisure, and $f'(h_t)$ is the derivative of the informal technology to informal labor.

the time constraint (Equation 2.2.2), the budget constraint (Equation 2.2.3), and the cash-in-advance constraint (Equation 2.2.4). The intratemporal consumption Euler gives the relative price of non-tradable goods as a function of consumption allocations:

$$p_t^N = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{\frac{1}{\xi}} \tag{2.2.5}$$

2.2.2 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.

Corporations

A continuum of corporations, indexed by $j \in [0,1]$, produces a specific variety j. Each corporation j hires domestic labor h_{jt}^F and physical capital k_{jt} to produce:

$$y_{jt}^N = k_{jt}^{\alpha_k}\left(z^F h_{jt}^F\right)^{\alpha_h^F} \tag{2.2.6}$$

where $\alpha_k, \alpha_h^F \geq 0$ capture the shares of capital and labor with $\alpha_k + \alpha_h^F \leq 1$. z^F is a scale parameter.

Each corporation j starts the current period with capital k_{jt} and external debt b_{jt} denominated in foreign currency, then issues bonds b_{jt+1} at an exogenous stochastic interest rate r_t at international markets, invests in the capital i_{jt}, and makes dividend payments d_{jt} to shareholders. 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 down the rise in prices, thereby generating currency mismatch effects as the domestic currency depreciates faster than prices rise. Besides, the government may recapitalize each corporation T_{jt} (equity injections) in a crisis.

The flow budget constraint in terms of the price of tradable goods is

$$d_{jt}+b_{jt}+i_{jt}=(1+\tau_y)\frac{P^N_{jt}}{P^T_t}y^N_{jt}-w_t h^F_{jt}+\frac{b_{jt+1}}{1+r_t}-\frac{a_p}{2}\left(\frac{P^N_{jt}}{P^N_{jt-1}}-\pi^N\right)^2+T_{jt}-\tau_y p^N_t y^N_t \quad (2.2.7)$$

The output is subsidized by τ_y to correct distortions due to monopolistic competition (Rotemberg and Woodford, 1999). The subsidy is funded by lump-sum taxes on all corporations.[8]

Capital accumulation is also 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 capital 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:

$$i_{jt}=k_{jt+1}-(1-\delta)k_{jt}+\frac{a_k}{2}\left(\frac{k_{jt+1}}{k_{jt}}-1\right)^2 k_{jt} \quad (2.2.8)$$

where δ denotes the depreciation rate.

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

$$\frac{b_{jt+1}}{1+r_t}\leq \kappa_t k_{jt+1} \quad (2.2.9)$$

[8]The subsidy could also be financed by distortionary taxation. That would not qualitatively affect the predictions of the model.

Corporations' capacity to finance investment is also limited by domestic equity market frictions:

$$\underline{d} \leq d_{jt} \tag{2.2.10}$$

where $\underline{d}$ shows the lowest bound on dividend payments. This constraint plays very crucial roles in model dynamics to generate realistic crisis dynamics. The external borrowing constraint first binds. The tight borrowing regime pressures corporations to reduce dividend payments to shareholders. However, domestic financial frictions prevent corporations from reducing dividend payments below the bound or raising new shares from households, thereby forcing them to cut down investment very sharply to satisfy the dividend constraint.

Let $s_t \equiv \{z_t, r_t, \kappa_t\}$, K_t, B_t, m^s_{t-1} and p^N_{t-1} denote exogenous states, aggregate capital and bond holdings, and real money supply and the relative price of non-tradable goods in the previous period. Then, the aggregate state vector is expressed as $S_t \equiv \{s_t, K_t, B_t, m^s_{t-1}, p^N_{t-1}\}$. k_{jt} and b_{jt} denote private capital and bond holdings of each corporation. Since households own corporations, the stochastic discount factor for the corporation's problem is

$$n(S_t, S_{t+1}) = \beta \frac{\left(c^{\nu}_{t+1} l^{1-\nu}_{t+1}\right)^{-\sigma}}{\left(c^{\nu}_{t} l^{1-\nu}_{t}\right)^{-\sigma}} \tag{2.2.11}$$

Let $W(k_{jt}, b_{jt}, S_t)$ denote the dividend market value of each corporation. The representative corporation chooses allocations to maximize the shareholder value given prices, government policies, and the output subsidy:

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

where $\Gamma_t \equiv \{d_{jt}, h^F_{jt}, k_{jt+1}, b_{jt+1}, P^N_{jt}\}$ and subject to the budget constraint (Equation 2.2.7), capital accumulation technology (Equation 2.2.8), collateral constraint (Equation 2.2.9), and dividend constraint (Equation 2.2.10).

The following first-order condition to the price of a variety j shows the distortionary costs of inflation on labor demand:

$$(1+\eta_t)\left((\gamma-1)p_t^N y_t^N(1+\tau_y) - w_t h_t^F \frac{\gamma}{\alpha_h^F} + a_p\left(\pi_t^N - \pi^N\right)\pi_t^N\right) = \mathbb{E}_t\left\{n(S_t, S_{t+1})\left(1+\eta_{t+1}\right)a_p \left(\pi_{t+1}^N - \pi^N\right)\pi_{t+1}^N\right\}$$

I suppose that corporations are identical, thus drop index j. η_t is the Lagrange multiplier associated with the dividend constraint. Suppose that nominal frictions disappear $a_p = 0$, then the condition is reduced to:

$$\frac{\gamma-1}{\gamma}\alpha_h^F \frac{p_t^N y_t^N}{h_t^F}(1+\tau_y) = w_t$$

where the left (right) hand side denotes the marginal value (cost) of hiring an additional unit of labor. Then, the output subsidy is given by $\tau_y = \frac{1}{\gamma-1}$ completely corrects monopolistic distortions.

Final Goods Producers

Final good producers use Dixit-Stiglitz aggregation technology to produce a composite good y_t^N from intermediate goods:

$$y_t^N = \left[\int_0^1 \left(y_{jt}^N\right)^{\frac{\gamma-1}{\gamma}} dj\right]^{\frac{\gamma}{\gamma-1}}$$

where $\gamma > 1$ shows the elasticity of substitution among different varieties. The aggregate price in the official non-tradable sector is

$$P_t^N = \left[\int_0^1 \left(P_{jt}^N\right)^{1-\gamma} dj\right]^{\frac{1}{1-\gamma}}$$

Cost minimization gives the optimal demand for each variety j:

$$y_{jt}^N = \left(\frac{P_{jt}^N}{P_t^N}\right)^{-\gamma} y_t^N$$

2.2.3 Government

The policymaker decides income taxes τ_t, inflation in the non-tradable sector π_t^N, real money supply m_t^s, the scale of recapitalization T_t, and government expenditures g_t^N.[9]

The domestic currency depreciation then follows from the following equality:

$$\frac{p_t^N}{p_{t-1}^N} = \frac{P_t^N/e_t}{P_{t-1}^N/e_{t-1}} = \frac{\pi_t^N}{\epsilon_t} \tag{2.2.12}$$

given p_{t-1}^N.

Money transfers are

$$P_t^T T^m = M_t^s - M_{t-1}^s, \quad T_t^m = m_t^s - \frac{m_{t-1}^s}{\epsilon_t}$$

where $m_t^s = \frac{M_t^s}{P_t^T}$.

The government's budget constraint is

$$p_t^N g_t^N + T_t = \tau_t w_t h_t^F + m_t^s - \frac{m_{t-1}^s}{\epsilon_t}$$

2.2.4 Competitive Equilibrium

In the competitive equilibrium, I suppose that the policymaker sets government expenditures, income taxes, and the scale of recapitalization to zero to show the relative effectiveness of interventions in the following sections as well as stabilizes inflation.

[9] I could also suppose that the policymaker decides aggregate expenditure, then it allotted to tradable and non-tradable goods in fixed proportion to modest computational costs such that:

$$g_t^N = \phi g_t, \quad g_t^T = (1-\phi) g_t$$

Then, the price of government expenditure is

$$p_t^g = \phi p_t^N + (1-\phi)$$

The main results would still carry through under this assumption.

Money market clears:

$$m_t^d = m_t^s = m_t \tag{2.2.13}$$

The binding cash-in-advance constraint gives the money supply, and all seigniorage revenue is rebated to households as lump-sump transfers. Then, Equation 2.2.12 gives the domestic currency depreciation.

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

$$c_t^T + b_t + k_{t+1} = y_t^T + \frac{b_{t+1}}{1+r_t} + (1-\delta)k_t - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 \tag{2.2.14}$$

The resource constraint for non-tradable goods is

$$c_t^N + \Gamma(z_t) = y_t^N + f(h_t^I) \tag{2.2.15}$$

Definition 2.1 (The Recursive Competitive Equilibrium). *Given exogenous states* $s_t \equiv \left\{y_t^T, r_t, \kappa_t\right\}$, *aggregate states* $S_t \equiv \left\{s_t, K_t, B_t, m_{t-1}, p_{t-1}^N\right\}$, *government policies* $\Omega(S_t) \equiv \left\{\tau_t, m_t, \pi_t^N, g_t^N, T_t, \epsilon_t\right\}$, *and the output subsidy* $\tau_y = \frac{1}{\gamma-1}$, *the recursive competitive equilibrium consists of the equity value* $W(k_t, b_t, S_t)$ *of each corporation, the stochastic discount factor* $n(S, S')$, *policy functions for households* $\hat{c}(S_t;\Omega(S_t))$, $\hat{c}^T(S_t;\Omega(S_t))$, $\hat{c}^N(S_t;\Omega(S_t))$, $\hat{h}^F(S_t;\Omega(S_t))$, $\hat{h}^I(S_t;\Omega(S_t))$, $\hat{l}(S_t;\Omega(S_t))$, $\hat{m}^d(S_t;\Omega(S_t))$, $\hat{z}(S_t;\Omega(S_t))$, *policy functions for corporations* $\hat{d}(S_t;\Omega(S_t))$, $\hat{h}^F(S_t;\Omega(S_t))$, $\hat{b}'(S_t;\Omega(S_t))$, $\hat{k}'(S_t;\Omega(S_t))$, *prices* $\hat{p}^N(S_t;\Omega(S_t))$, $\hat{w}(S_t;\Omega(S_t))$, $\hat{\eta}(S_t;\Omega(S_t))$, $\hat{\mu}(S_t;\Omega(S_t))$ *and the law of motion of the aggregate variables* $S_{t+1} = \Lambda(S_t)$ *such that*

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

2. *Policy functions* $\hat{d}(S_t;\Omega(S_t))$, $\hat{h}^F(S_t;\Omega(S_t))$, $\hat{b}'(S_t;\Omega(S_t))$, $\hat{k}'(S_t;\Omega(S_t))$ *solve the cor-*

poration'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 external borrowing and domestic equity market constraints. The resource constraints Equation 2.2.14 and Equation 2.2.15 both hold.*

4. *The money market clears. Equation 2.2.13 holds.*

5. *The law of motions are consistent with individual states:*

$$\hat{K}'(S_t; \Omega(S_t)) = \hat{k}'(S_t; \Omega(S_t)) \quad \textit{and} \quad \hat{B}'(S_t; \Omega(S_t)) = \hat{b}'(S_t; \Omega(S_t))$$

and the stochastic processes for y_t^T, r_t, κ_t.

6. *The stochastic discount factor is the representative household's marginal rate of substitution Equation 2.2.11.*

7. *Time constraint holds:*

$$\hat{l}(S_t; \Omega(S_t)) = 1 - \hat{h}^F(S_t; \Omega(S_t)) - \hat{h}^I(S_t; \Omega(S_t))$$

2.3 Time-Consistent Optimal Policies

The policymaker decides policies each period by taking as given the policies of its future-self. I find the fixed point of policies that represent the current and future policymakers.

I first consider the case in which the policymaker not permitted to recapitalize corporations. Then, I suppose that the policymaker can spend government revenues to finance the recapitalization of corporations and price support policies to display the relative effectiveness of each policy. The policymaker may also tax capital inflows together with recapitalization to moderate ex-ante risk-taking.

2.3.1 Optimal Devaluation and Income Taxes

Now, the policymaker decides inflation in the non-tradable sector, money supply, and income taxes as well as rebates government revenue as lump-sum transfers to households, but can not recapitalize corporations. More conservative inflationary policies restrict the arbitrary increase in the external debt burden under nominal frictions in a crisis, thereby helping to accelerate capital formation.

Definition 2.2 (**Optimal Time-Consistent Devaluation and Income Taxes**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, l_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t, c_t^T, c_t^N, h_t^F, h_t^I, l_t, z_t, d_t, k_{t+1}, b_{t+1}, m_t, \tau_t, \pi_t^N, \epsilon_t\right\}$ *and subject to the competitive equilibrium conditions(Equation B.1 - Equation B.24), but now*

1. *the government's budget constraint is*

$$T_t = \tau_t w_t h_t^F + m_t - \frac{m_{t-1}}{\epsilon_t}$$

2. *The household's budget constraint is replaced by*

$$c_t^T + p_t^N c_t^N + m_t^d + p_t^N \Gamma(z_t) = y_t^T + (1-\tau_t) w_t h_t^F + d_t + \frac{m_{t-1}^d}{\epsilon_t} + T_t^m + p_t^N f(h_t^I) + T_t$$

3. *perceived policies coincide with actual policies.*

2.3.2 Optimal Recapitalization

Since domestic financial frictions stop the flow of funds from households to corporations in a crisis, the policymaker finds it optimal to extract resources from households and transfer these resources to corporations' balance sheets. This policy accelerates the recapitalization of the official production sector.

Definition 2.3 (**Optimal Time-Consistent Recapitalization**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \left\{ u(c_t, l_t) + \beta \mathbb{E}_t V\left(S_{t+1}\right) \right\}$$

where $\Gamma_t \equiv \left\{ c_t, c_t^T, c_t^N, h_t^F, h_t^I, l_t, z_t, d_t, k_{t+1}, b_{t+1}, m_t, \tau_t, \pi_t^N, \epsilon_t, T_t \right\}$ *and subject to the competitive equilibrium conditions(Equation B.1 - Equation B.24), but now*

1. *the government's budget constraint is*

$$T_t = \tau_t w_t h_t^F + m_t - \frac{m_{t-1}}{\epsilon_t}$$

2. *the corporation's budget constraint is replaced by*

$$\begin{aligned} d_t = p_t^N y_t^N - w_t h_t^F + (1-\delta) k_t - k_{t+1} - \frac{a_k}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t - b_t + \frac{b_{t+1}}{1 + r_t} \\ - \frac{a_p}{2} \left(\pi_t^N - \pi^N \right)^2 + T_t \end{aligned}$$

3. *perceived policies coincide with actual policies.*

2.3.3 Optimal Price Support

The expansionary fiscal policies supporting the relative price of non-tradable goods also relax the balance sheets of corporations.

Definition 2.4 (**Optimal Time-Consistent Price Support**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions* *of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, l_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t, c_t^T, c_t^N, h_t^F, h_t^I, l_t, z_t, d_t, k_{t+1}, b_{t+1}, m_t, \tau_t, \pi_t^N, \epsilon_t, g_t^N\right\}$ *and subject to the competitive equilibrium conditions(Equation B.1 - Equation B.24), but now*

1. *the government's budget constraint is*

$$p_t^N g_t^N = \tau_t w_t h_t^F + m_t - \frac{m_{t-1}}{\epsilon_t}$$

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

$$c_t^N + g_t^N + \Gamma(z_t) = y_t^N + f(h_t^I)$$

3. *perceived policies coincide with actual policies.*

To see how the expansionary fiscal policies support the relative price of non-tradable goods, thereby relaxing the corporate balance sheets, plug in the market clearing condition for non-tradable goods into Equation 2.2.5:

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

2.3.4 Optimal Capital Controls

Since anticipated interventions create strong incentives to build up excessive risk in pre-crisis, the policymaker may find it optimal to tax capital inflows at the rate of τ_t^c to alleviate moral hazard issues.

Definition 2.5 (**Optimal Time-Consistent Capital Controls**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions* *of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, l_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t, c_t^T, c_t^N, h_t^F, h_t^I, l_t, z_t, d_t, k_{t+1}, b_{t+1}, m_t, \tau_t, \pi_t^N, \epsilon_t, g_t^N, T_t, \tau_t^c\right\}$ *and subject to the competitive equilibrium conditions(Equation B.1 - Equation B.24), but now*

1. *the government's budget constraint is*

$$p_t^N g_t^N + T_t = \tau_t w_t h_t^F + \tau_t^c \frac{b_{t+1}}{1+r_t} + m_t - \frac{m_{t-1}}{\epsilon_t}$$

2. *the corporation's budget constraint is replaced by*

$$d_t = p_t^N y_t^N - w_t h_t^F + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + (1-\tau_t^c)\frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 + T_t$$

3. *the market clearing condition for non-tradable goods is replaced by*

$$c_t^N + g_t^N + \Gamma(z_t) = y_t^N + f(h_t^I)$$

4. *the first-order-condition to* b_{t+1} *is replaced by*

$$(1+\eta_t)(1-\tau_t^c) = (1+r_t)\beta \mathbb{E}_t n(S_t, S_{t+1})(1+\eta_{t+1}) + \mu_t$$

   where μ_t *and* η_t *are the Lagrangian multipliers associated with external borrowing and domestic equity market constraints.*

5. *perceived policies coincide with actual policies.*

2.4 Quantitative Analysis

2.4.1 Solution Method

The model needs to be solved by global solution methods due to the occasionally binding constraints. I solve optimal time-consistent policies by value function iteration, and the competitive equilibrium allocations by policy function iteration, and approximate policy functions outside grid points by cubic B-splines.

2.4.2 Calibration

I estimate the model parameters to match model moments with their empirical counterparts in the data of an average developing world economy from 1980 to 2015. Table 2.1 reports these values.

I estimate the transition probabilities of there exogenous states, tradable endowments, interest rates, and financial shocks by supposing that financial shocks are orthogonal to interest rates and tradable endowments. I compute the borrowing rate for each country as the sum of EMBI-spreads and US Treasury bill rates. Tradable goods consist of agriculture, forestry, manufacturing, and mining.

I use the standard values σ, ν, α_k, α_h^F, α_h^I, γ. β and δ target capital/output and investment/output ratios. I set z^F to 0.12 to target official non-tradable goods/GDP ratio and z^I to match the average size of the informal economy/GDP ratio. a_k (a_p) captures the standard deviation of the investment/output ratio (the non-tradable inflation). a matches the share of non-tradable goods in aggregate consumption. I stick to the widespread limited liability constraint $\underline{d} = 0$.

2.4.3 Results

To show the effects of a tight domestic equity constraint on model dynamics, I first solve the model with ($\underline{d} = 0$) and without ($\underline{d} = -\infty$) domestic financial frictions. Figure 2.2 shows the equilibrium law of motions for the debt and capital in the next period as a function of the debt in the current period. I fix tradable endowments and interest rates at their mean values.

The debt in the following period is increasing with the debt level in the current period in the high external borrowing regime with and without domestic financial frictions. In contrast, capital in the next period is strictly diminishing as with the debt level in the current period. High debt levels significantly increase the probability of future binding constraints, which lowers incentives to increase external borrowing to finance investment even in the high borrowing regime. In other words, high debt levels raise the risk premium of investment, thereby leading to lower resource allocations to investment.

The quantitative analysis shows that the external borrowing constraint first binds. Although the tight external borrowing regime leads to a sudden reversal in the law of motions of next period debt and capital, the tight domestic credit regime induces more striking differences in the policy functions, since the tight dividend constraint pressures corporations to sharply cut down investment. In other words, domestic financial frictions prevent corporations from raising new equity from households to finance investment when the external borrowing capacity contracts. Next period debt also drops sharply in the tight domestic credit regime as investment cuts down very sharply. Since households can not recognize that resources are more valuable within corporations in the tight credit regime, they are not willing to transfer resources to the formal production sector. However, the policymaker can extract resources and transfer them to corporations' balance sheets to accelerate the recapitalization of this sector in a crisis. Thus, government interventions are socially desirable in this framework since resources are more valuable in the formal production sector in a crisis, and interventions facilitate the transfer of funds from households to the formal production sector.

To show the relative effectiveness of government interventions, I first suppose that they are not available. The policymaker decides inflation in the non-tradable sector, income taxes, and money supply, but all revenues are rebated as lump-sum transfers to households. Figure 2.3 depicts the equilibrium policy functions of the competitive equilibrium (CE) and the policymaker's problem without ($OP1$) and with ($OP2$) recapitalization.

The policymaker finds it optimal to allow a smaller devaluation without interventions since devaluation significantly increases the debt burden in the official production sector as the exchange rate depreciates faster than prices rise. Nominal rigidities, along with domestic financial frictions, call for a more conservative devaluation policy compared to the inflation stabilization policy. Through this policy, the policymaker limits the arbitrary increase in the external debt burden, thereby helping the formal production sector to recapitalize. However, the benefits of this policy are limited as it reduces the tax burden in the informal sector, thereby shifting employment from the formal production sector to the informal sector. Since this policy also reduces the tax burden on transactions made using cash, shoppers tend to increase the share of these transactions.

The policymaker is now permitted to recapitalization corporations financed through tax and seigniorage revenues in a crisis. Transferring resources to corporations' balance sheets in the tight credit regimes relaxes the equity constraint, thereby significantly accelerating the recapitalization in the formal production sector. The quantitative analysis reveals that the policymaker is more inclined to impose an inflation tax rather than income taxes on households to alleviate the under-capitalization of corporations. The growing tax burden in the informal sector shifts employment to the formal production sector. The share of transactions made using credit also increases.

To compute limiting distributions of debt and capital showed in Figure 2.4, I simulate the model 110,000 times and discard 10,000 as burn-in. The limiting distributions of debt and capital in the competitive equilibrium are on the left of the distributions in optimal policies. Interventions decrease precautionary incentives, thereby leading to excessive borrowing. Limiting distributions have fat tails on the left that reflect the precautionary motives due to the external borrowing constraint. The tight borrowing constraint increases the probability of a binding future dividend constraint that brings about very sharp consumption drops. Thus, corporations try not to hit the borrowing constraint too.

To reveal how optimal policies vary as the informal economy grows, I recalibrate the parameter of the informal production technology (z^I) to grow the share of the informal economy. Figure 2.5 compares the equilibrium law of motions under the presence of the low ($OP1$) and high ($OP2$) shares of the informal economy. The figure denotes that the domestic currency depreciates more strongly as the informal economy grows.

Besides, I study whether expansionary fiscal policies can also accelerate the recapitalization of corporations. This policy expanding the demand for non-tradable goods raises the relative price, thereby relaxing the tightness of the equity constraint. However, the quantitative analysis reveals that the costs of increasing government expenditure to support the relative price in a crisis outweigh the benefits of this policy.

Even though anticipated interventions lead to excessive leverage in pre-crisis, I find that capital inflow taxes can not yield significant welfare gains, but lower the frequency of a crisis.

2.5 Welfare Analysis

I compute welfare gains as the percentage increase in aggregate consumption that makes households indifferent between government interventions and the competitive equilibrium. In particular, I compute

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t^{\nu} l_t^{1-\nu}\right)^{1-\sigma}}{1-\sigma} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left((c_t(1+\rho))^{\nu} l_t^{1-\nu}\right)^{1-\sigma}}{1-\sigma}$$

where ρ is the percentage change in aggregate consumption.

Figure 2.6 reports welfare gains of optimal recapitalization under the presence of the high and low shares of the informal economy. The recapitalization of corporations is much more socially desirable as the size of the informal economy grows. In other words, this policy yields higher welfare gains.

2.6 Conclusion

This paper studies the optimal way to finance the recapitalization of corporations under the presence of the informal economy. The quantitative analysis displays that the policymaker should allow a higher devaluation as the size of the informal economy grows to monetize interventions. This policy significantly raises welfare gains despite the currency mismatch effects.

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B Appendix

B.1 Feasible Debt Space

The maximum debt level guarantees that consumption allocations are positive and constraints are not violated. I find the maximum debt level for each capital stock. The numerical algorithm searches for equilibrium allocations within the feasible space. This section explains the numerical algorithm searching the maximum debt level in the worst exogenous state: y^T_{min}, r_{max} and κ_{min}. Let $b_f(k)$ denote the maximum debt level that the economy can sustain in the worst exogenous state. The following algorithm gives the feasible space $b_f(k)$ as a function of capital stock:

$$b_{ft}(k_t) = \max_{\Gamma_t} \left\{ p^N_t y^N_t - w_t h^F_t - \underline{d} + \frac{b_{t+1}}{1 + r_{tmax}} + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2} \left(\frac{k_{t+1}}{k_t} - 1 \right)^2 k_t \right\}$$

where $\Gamma_t \equiv \left\{ b_{t+1}, k_{t+1}, h^F_t \right\}$ and subject to

$$\frac{b_{t+1}}{1 + r_{tmax}} \leq \kappa_{tmin} k_{t+1}$$

where p^N_t and y^N_t are given by Equation 2.2.5 and Equation 2.2.6 respectively.

Households and corporations' first-order-conditions give the optimal labor demand in each sector and the share of credit goods as the solution of the following non-linear equations:

$$u_{2t} \left(1 + q_t \left(1 - z_t\right)\right) = \left(1 - \tau_t\right) w_t u_{1t}$$

$$w_t = p^N_t f' \left(h^I_t\right)$$

$$q_t = \frac{p^N_t \Gamma'(z_t)}{c^T_t + p^N_t c^N_t}$$

where q_t is

$$q_{t+1} = \frac{1}{\beta} \frac{u_{2t}}{p^N_t f'\left(h^I_t\right)} \mathbb{E}_t \left\{ \frac{p^N_{t+1} f'\left(h_{t+1}\right)}{u_{2t+1}} \epsilon_{t+1} \right\}$$

Market clearing conditions for tradable and non-tradable goods are

$$c_t^T = y_{tmin}^T - b_{ft}(k_t) + \frac{b_{t+1}}{1 + r_{tmax}} + (1 - \delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t$$

and

$$c_t^N + \Gamma(z_t) = y_t^N + f\left(h_t^I\right)$$

The feasible set is

$$\Theta = \{(b, k) \in \mathbb{R} \times \mathbb{R}, b \leq b_f(k)\}$$

The following numerical algorithm finds the maximum sustainable debt:

1. For given k, guess $b_{f,s}$ where $s = 0$ is the iteration number.
2. Using the above-described procedure, find $b_{f,s}$ at the iteration s.
3. Make sure that the tradable consumption is not negative.
4. Check convergence such that $sup_k \left[b_{f,s}(k) - b_{f,s-1}(k)\right] < \varepsilon$.
5. If not converged, start from step 2 and iterate until converge.

Figure 2.1 plots the feasible debt space. The maximum debt that the economy can sustain is increasing with the current capital stock. In the quantitative analysis, I find that the ergodic distribution of debt is within the feasible debt space.

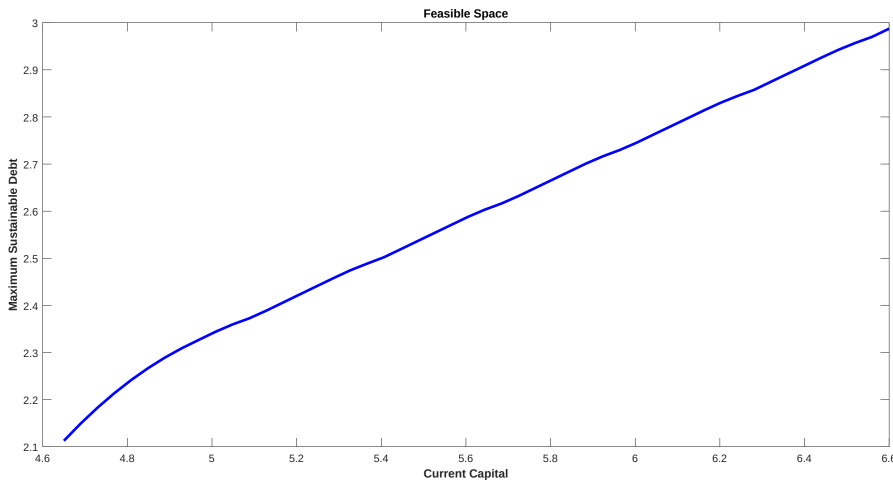

Figure 2.1: The feasible debt space.

B.2 Numerical Algorithm

Competitive Equilibrium

I solve the competitive equilibrium allocations by policy function iteration given government policies $\Omega(S_t)$, where aggregate grid space given as $S_t \equiv \left\{s_t, B_t, K_t, m_{t-1}, p^N_{t-1}\right\}$. I use B-spline interpolation methods to approximate functions outside grid points.

The computational algorithm can be summarized in the following steps:

1. Grid Points:

   First, I generate discrete grids for the aggregate state space: s_t x B_t x K_t x m_{t-1} x p^N_{t-1}

2. Feasible Debt Space:

   I compute the maximum debt the economy can sustain given government policies and capital stock K_t as in the subsection B.1.

3. Initial Guesses:

I determine initial guesses for policy functions as steady-state values and compute expectations using these guesses.

4. Equilibrium Policy Functions:

   I find the competitive equilibrium allocations by policy function iteration as follows:

   (a) Suppose that only the borrowing constraint Equation 2.2.9 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (b) Suppose that only the equity constraint Equation 2.2.10 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (c) Suppose that both collateral and equity constraints bind, then solve for the equilibrium allocations. Check whether constraints bind. If not, continue with the following step.

   (d) Suppose that both constraints are slack, then solve for the equilibrium allocations.

5. Expectations:

   I update agents' conditional expectations.

6. Convergence:

   Repeat from item 4 to item 5, until expected values and policy functions converge.

Time-Consistent Optimal Policies

The algorithm searches for time-consistent optimal policies. In other words, the algorithm searches for the fixed points of the policy functions that represent current and future policymakers. Given current and future policymakers' policies, private agents adjust their expectations and find their optimal reactions to the government's policies. Given the agents' expectations and future policies, the current policymaker maximizes the representative agent's welfare. The algorithm stops when current and future policymakers' policies coincide.

I approximate expectations, value functions, and policy functions. The algorithm iterates two loops. The outer loop iterates on expectations, while the inner loop iterates on the value function.

1. Grid Points:

   First, I generate discrete grids for the aggregate state space: s_t x B_t x K_t x m_{t-1} x p^N_{t-1}

2. Feasible Debt Space:

   I compute the maximum debt the economy can sustain given government policies and capital stock K_t as in the subsection B.1.

3. Initial Guesses:

   I determine initial guesses for policy functions as steady-state values and compute expectations and the value functions using these guesses.

4. Equilibrium Policy Functions:

   I find the competitive equilibrium allocations by policy function iteration as follows:

   (a) Suppose that only the borrowing constraint Equation 2.2.9 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (b) Suppose that only the equity constraint Equation 2.2.10 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

(c) Suppose that both collateral and equity constraints bind, then solve for the equilibrium allocations. Check whether constraints bind. If not, continue with the following step.

(d) Suppose that both constraints are slack, then solve for the equilibrium allocations.

5. Optimal Policies Given The Policy Functions:

   Given the competitive equilibrium policy functions, the policymaker chooses the policies that maximize the welfare at each grid point.

6. Converge of The Value Function:

   Repeat item 5, until the value function converges.

7. Expectations:

   Given the policy functions corresponding to the optimal policies computed in item 6, I update agents' expectations.

8. Convergence:

   Repeat from item 4 to item 7, until expectations, the value function and policy functions converge.

B.3 Competitive Equilibrium Conditions

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

$$\frac{dc_t}{dc_t^T} = \left[a\left(c_t^T\right)^{1-\frac{1}{\xi}} + (1-a)\left(c_t^N\right)^{1-\frac{1}{\xi})}\right]^{\frac{1}{1-\xi}} a\left(c_t^T\right)^{-\frac{1}{\xi}} \tag{B.2}$$

$$u_{1t} = \left(c_t^\nu l_t^{1-\nu}\right)^{-\sigma} \nu c_t^{\nu-1} l_t^{1-\nu} \tag{B.3}$$

$$u_{2t} = \left(c_t^\nu l_t^{1-\nu}\right)^{-\sigma} (1-\nu) c_t^\nu l_t^{-\nu} \tag{B.4}$$

$$\lambda_t = u_{1t}\frac{dc_t}{dc_t^T} \tag{B.5}$$

$$p_t^N = \frac{1-a}{a}\left(\frac{c_t^T}{c_t^N}\right)^{\frac{1}{\xi}} \tag{B.6}$$

$$y_t^N = k_t^{\alpha_k}\left(z^F h_t^F\right)^{\alpha_h^F} \tag{B.7}$$

$$f(h_t^I) = (z^I h_t^I)^{\alpha_h^I} \tag{B.8}$$

$$\Gamma(z_t) = \int_0^{z_t} \frac{x}{1-x} dx \tag{B.9}$$

$$c_t^T + b_t + k_{t+1} = y_t^T + \frac{b_{t+1}}{1+r_t} + (1-\delta)k_t - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 \tag{B.10}$$

$$c_t^N + \Gamma(z_t) = y_t^N + f(h_t^I) \tag{B.11}$$

$$d_t = p_t^N y_t^N - w_t h_t^F + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + \frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2 \tag{B.12}$$

$$(1+\eta_t) = (1+r_t)\beta\mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}(1+\eta_{t+1})\right\} + \mu_t \tag{B.13}$$

$$(1+\eta_t)\left(1 + a_k\left(\frac{k_{t+1}}{k_t} - 1\right)\right) = \beta\mathbb{E}_t\left\{\frac{\lambda_{t+1}}{\lambda_t}\left[1 - \delta + \frac{a_k}{2}\left(\left(\frac{k_{t+2}}{k_{t+1}}\right)^2 - 1\right) + \frac{\alpha_k}{\alpha_h^F}\frac{w_{t+1}h_{t+1}}{k_{t+1}}\right](1+\eta_{t+1})\right\} + \kappa_t\mu_t \tag{B.14}$$

$$(1+\eta_t)\left((\gamma-1)p_t^N y_t^N(1+\tau_y) - w_t h_t^F \frac{\gamma}{\alpha_h^F} + a_p\left(\pi_t^N - \pi^N\right)\pi_t^N\right) = \mathbb{E}_t\left\{n(S_t, S_{t+1})\left(1+\eta_{t+1}\right)a_p \left(\pi_{t+1}^N - \pi^N\right)\pi_{t+1}^N\right\} \tag{B.15}$$

$$u_{2t}\left(1+q_t\left(1-z_t\right)\right)=w_t u_{1t} \tag{B.16}$$

$$w_t=p_t^N f'\left(h_t^I\right) \tag{B.17}$$

$$q_t=\frac{p_t^N \Gamma'(z_t)}{c_t^T+p_t^N c_t^N} \tag{B.18}$$

$$q_{t+1}=\frac{1}{\beta}\frac{u_{2t}}{p_t^N f'\left(h_t^I\right)}\mathbb{E}_t\left\{\frac{p_{t+1}^N f'\left(h_{t+1}\right)}{u_{2t+1}}\epsilon_{t+1}\right\} \tag{B.19}$$

$$\mu_t\left(\frac{b_{t+1}}{1+r_t}-\kappa_t k_{t+1}\right)=0, \quad \mu_t\geq 0 \tag{B.20}$$

$$\eta_t\left(\underline{d}-d_t\right)=0, \quad \eta_t\geq 0 \tag{B.21}$$

$$\epsilon_t=\frac{p_{t-1}^N}{p_t^N}\pi_t^N \tag{B.22}$$

$$i_t=k_{t+1}-(1-\delta)k_t+\frac{a_k}{2}\left(\frac{k_{t+1}}{k_t}-1\right)^2 k_t \tag{B.23}$$

$$l_t=1-h_t^F-h_t^I \tag{B.24}$$

B.4 Figures

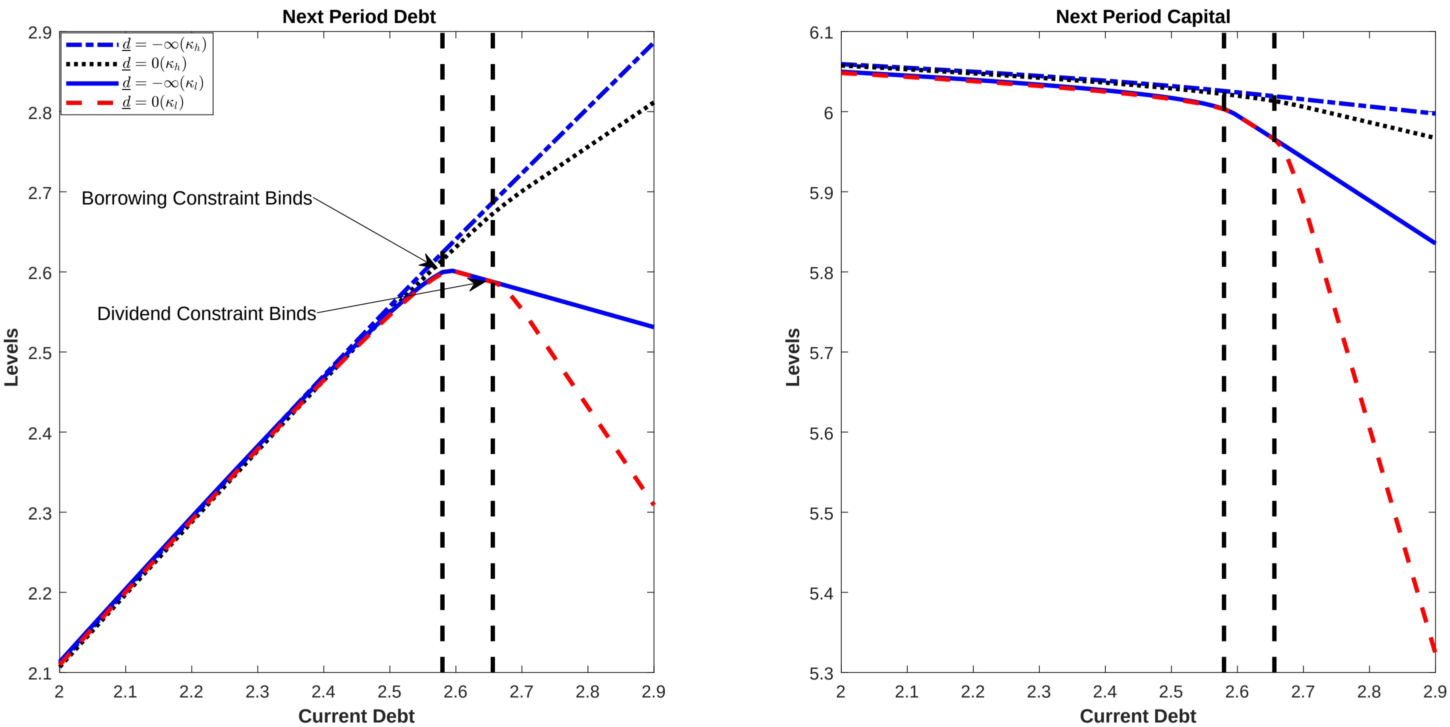

Figure 2.2: The dashed blue (black) line shows the policy functions without (with) domestic equity market frictions ($\underline{d} = 0$) $\underline{d} = -\infty$ in the high external borrowing regime κ_h. The solid blue and dashed red lines denote policy functions in the low borrowing regime κ_l with $\underline{d} = -\infty$ and $\underline{d} = 0$ respectively.

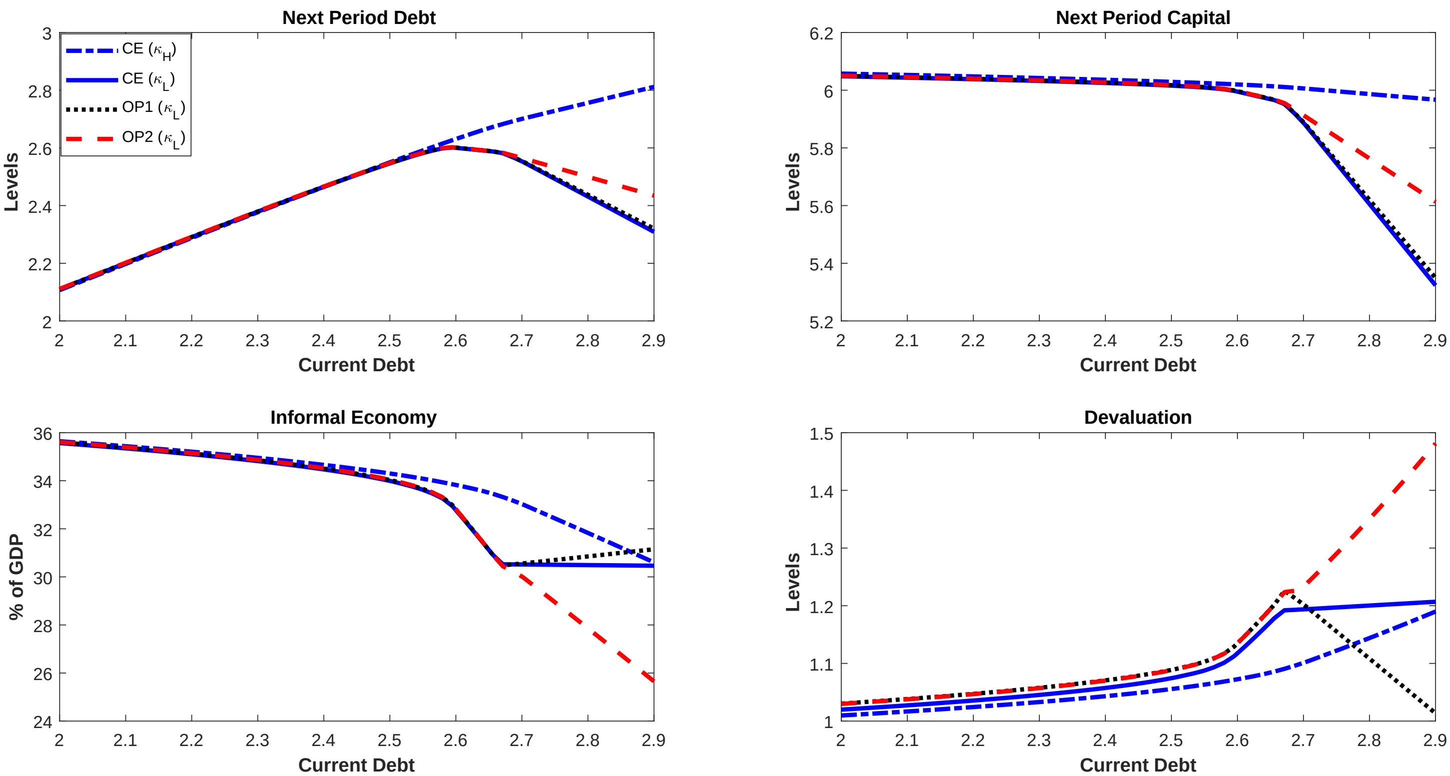

Figure 2.3: The dashed (solid) blue line shows the policy functions in the competitive equilibrium (CE) in the high (low) borrowing regime. $OP1$ ($OP2$) refers to optimal policies without (with) interventions in the tight borrowing regime.

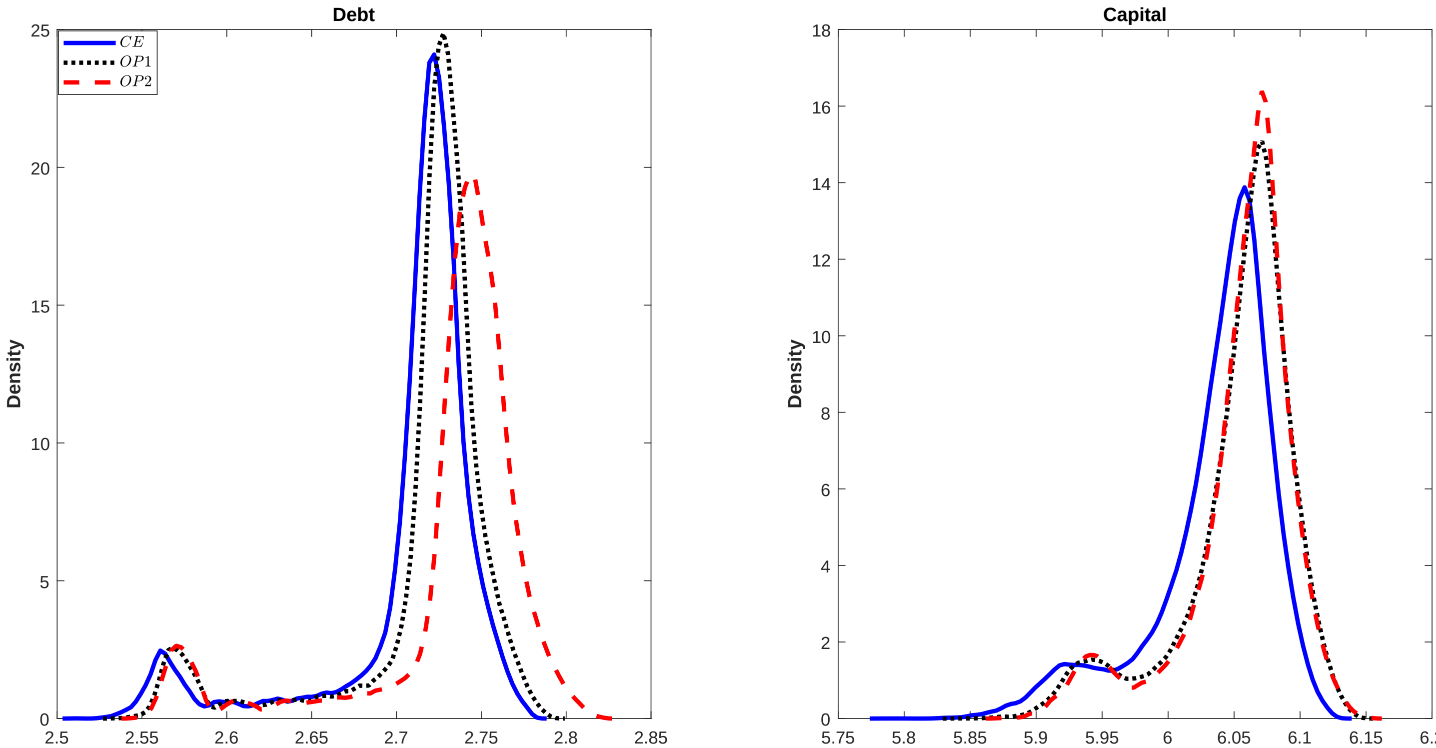

Figure 2.4: The solid blue line shows the limiting distributions in the competitive equilibrium (CE). $OP1$ ($OP2$) displays limiting distributions without (with) interventions.

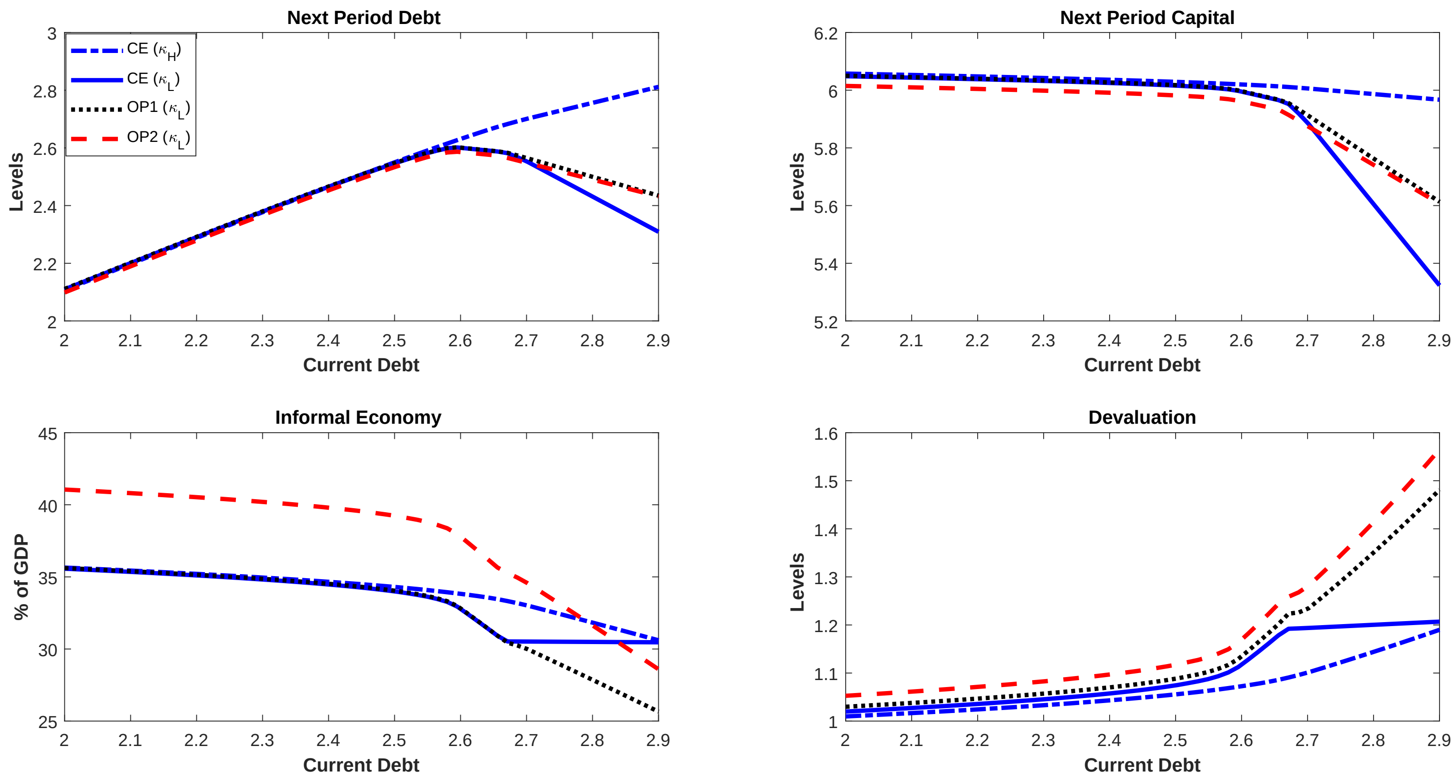

Figure 2.5: The dashed (solid) blue line shows the policy functions in the competitive equilibrium (CE) in the high (low) borrowing regime. $OP1$ ($OP2$) refers to optimal policies with interventions in the tight borrowing regime with a low (high) share of the informal economy.

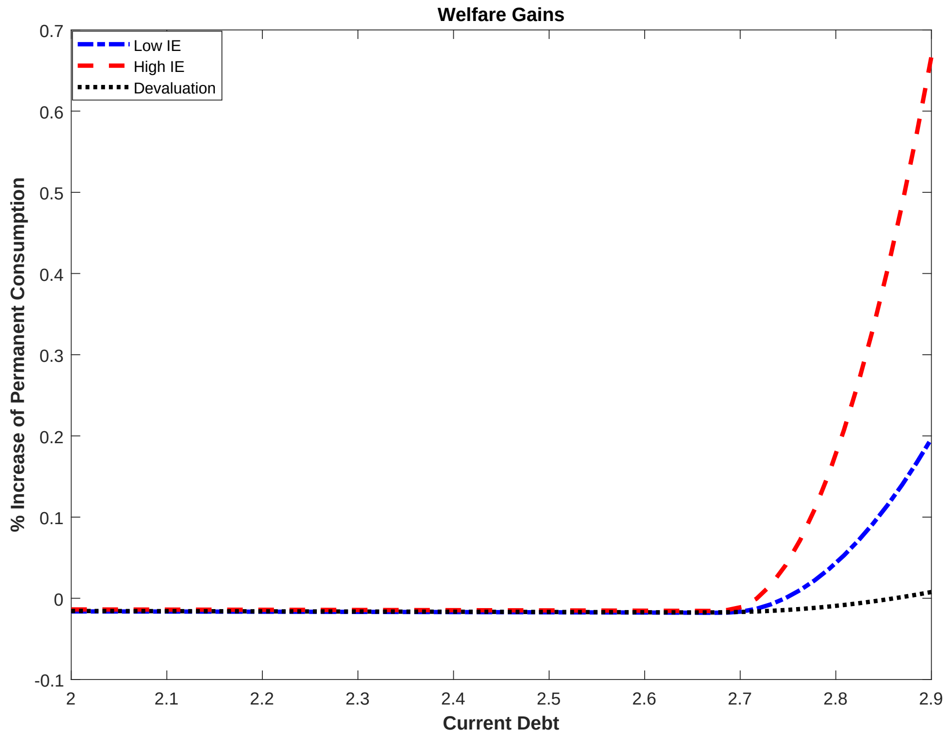

Figure 2.6: High (Low) IE displays the welfare gains under the presence of the high (low) share of the informal economy.

B.5 Tables

Parameter	Description	Value	Target
σ	Risk Aversion	2.00	Standard
β	Discount Factor	0.96	K/Y
δ	Depreciation Rate	0.02	I/Y
α_k	Capital Share	0.33	Standard
α_h^F	Labor Share	0.53	Standard
α_h^I	Labor Share	0.42	Standard
z^F	Output Scale	0.12	y^N/GDP
z^I	Output Scale	0.94	IE/GDP
ν	Consumption Sha. in Util.	0.30	Standard
a	Share of Non-Trad.	0.42	c^N/c^T
ξ	Elas. Subs. Tra. and Non-tra.	0.44	Standard
$\underline{d}$	Equity Threshold	0.00	Standard
a_p	Price Adjustment Cost	0.40	Std. of π_t^N
a_k	Capital Adjustment Cost	9.00	Std. of i_t
γ	Elasticity of Subs.	3.00	Standard

Table 2.1: Parameter Values

Chapter 3

Bailouts, Moral Hazard and the Currency Composition of Sovereign Debt

3.1 Introduction

The developing economies had difficulties to place debt in their currencies in world markets sixteen years ago, but this trend has recently reversed. In particular, Du and Schreger (2016); Arslanalp and Tsuda (2014) show that the average share of government debt denominated in domestic currency (DC) has approximately increased from 15% to 60% of external debt for the 2003-2014 period. I first ask how the recently growing share of DC government debt affects the ex-ante risk-taking due to anticipated bailouts in the production sector, which, in turn, affects the currency composition of government debt.

Massive-scale bailouts accompany banking crises in the developing world. In particular, Valencia and Laeven (2015) have documented that the average scale of bailouts accounts for

12% (30%) of GDP (financial assets) in the developing world - the scale ranging from 0.06% (0.3%) to 57% (135%). Government interventions to recapitalize the production sector or raise asset prices are very prevalent in the emerging world. Farhi and Tirole (2012) show that anticipated interventions create incentives to build up higher leverage in pre-crisis. Besides, Ottonello and Perez (forthcoming) contribute that the growing share of government debt denominated in DC can form a hedge against adverse shocks. In line with these perspectives, the paper studies whether the growing share of DC debt creates incentives to take on more risk ex-ante. The paper also examines how bailouts affect the currency composition of government debt.

It is now more crucial to analyze the interaction between the currency composition of sovereign debt and ex-ante risk-taking in the production sector, given that the share of DC debt has significantly grown in recent years. In particular, Du and Schreger (2016); Arslanalp and Tsuda (2014) provide that the share on average has grown from 15% to 60% of total external government debt in the last two decades. However, the private sector still accumulates substantial debt denominated in foreign currency (FC). In particular, the share of private debt denominated in DC has only increased by 10% in the same period.

Motivated by these facts, I develop a dynamic stochastic general equilibrium model to study whether bailouts drive the currency composition of government debt that, in turn, leads to building up ex-ante risks under nominal and financial frictions. The model builds on Bianchi (2016); Bianchi and Mendoza (2018).

The model economy consists of risk-averse households, firms, risk-neutral international lenders, and a government. Households supply labor to firms and are the equity owners of firms, thereby receiving wage and dividend payments from the production sector. Firms produce differentiated goods under monopolistic competition. They import inputs from abroad to produce. They can issue intertemporal bonds in FC and intra-temporal loans to finance a constant fraction of imported inputs in advance, but expected asset prices limit total borrowing. Firms also face frictions in the domestic equity market. In particular, they can not raise new equity from households in a crisis. Households do not transfer funds to the production sector since they can not internalize that by doing so, they can receive higher dividend and wage payments in the future. This constraint is very crucial to generate realistic model dynamics. Firms are also subject to nominal frictions, thereby a faster domestic currency depreciation than prices rise tightens the dividend constraint.

The normative analysis shows that the competitive equilibrium is inefficient that generates scope for interventions. In particular, firms can not recognize how external borrowing affects asset prices, thereby affecting the tightness of the borrowing constraint. Besides, they over-demand labor since they can not recognize that they can turn wages in favor of their balance sheets by reducing employment. However, the social planner can internalize these inefficiencies. Thus, the planner can reduce borrowing and employment to relax borrowing and financial constraints.

After characterizing the inefficiencies in the competitive equilibrium, I focus on time-consistent optimal policies. I solve the competitive equilibrium by policy function iteration and time-consistent policies by value function iteration. I first consider the case where the policymaker can only impose income taxes on households and debt taxes on firms to alleviate over-borrowing and over-employment in the production sector. I then extend the basic setup by introducing government debt denominated both in FC and DC. I focus on time-consistent policies for two reasons. First, the Ramsey planner may promise to eliminate bailouts, but this promise is not credible in a crisis since it is optimal to alleviate the drop in asset prices. Second, the Ramsey planner may promise not to diminish the real value of nominal debt to raise the price of debt, but when debt is issued, this promise is also not credible.

Accordingly, I first solve the case where the policymaker can only impose income taxes on households to transfer resources from households to firms. In that case, I find that while bailouts relax the tightness of the dividend constraint in a crisis, they create excessive leverage in pre-crisis. I then solve the second case where bailouts are supplanted by capital controls to limit ex-ante borrowing and find that bailouts significantly raise welfare gains in the second case. In particular, over-borrowing in the first case calls for more substantial scale bailouts in a crisis. Given that distortionary income taxes can only finance bailouts, it is too costly to increase income taxes to bail out the production sector. Also, over-borrowing excessively decreases asset prices. Thus, the benefits of bailouts are limited.

I show that firms over-demand labor in the competitive equilibrium since they can not recognize that they can turn wages in favor of their balance sheets by reducing employment. Thus, I also examine whether payroll taxes are effective in alleviating the over-employment in the production sector. In particular, I suppose that the policymaker can now impose payroll taxes and debt taxes on firms to alleviate over-borrowing and over-employment and then transfers tax revenue as lump-sum payments to firms' balance sheets. While payroll taxes and debt taxes are effective in alleviating market failure, I find that bailouts lead to higher welfare gains.

I then solve the extended setup. Risk-neutral international lenders hold both nominal and real government debts. The policymaker can reduce the real value of nominal debt through an inflation tax. I first suppose that the policymaker can not offer bailouts to the production sector to show the relative effectiveness of bailouts. Thus, I reveal how bailouts affect the currency composition of government debt as well as ex-ante risk-taking in the production sector.

When bailouts are not available, the policymaker allows smaller inflation in a crisis. In that case, the policymaker tends to follow more conservative inflationary policies. Fear of depreciation is prevalent since inflation distorts labor demand as well as costs real resources.

Furthermore, anticipated dilution risks significantly reduce the price of nominal government debt. Rational foreign lenders internalize the incentives to reduce the real value of nominal claims. Thus, they accept to lend at a lower price as dilution risks rise. Thereby, the policymaker tilts the currency composition of government to FC to borrow at a lower price. I also find that the DC share of government debt is pro-cyclical. In particular, the share rises in expansions but decreases in contractions.

I now suppose that the policymaker can bail out the production sector. The policymaker can finance bailouts through fiscal policy and monetary policy. In particular, the policymaker can now impose an inflation tax on foreign lenders. By doing so, the policymaker can transfer resources from debt to bailout payments since inflation reduces the real value of nominal claims to foreign lenders. The growing share of debt denominated in DC, on the one hand, can form a hedge against adverse financial shocks. On the other hand, it results in a build-up of higher leverage in pre-crisis since the policymaker may bail out the production sector instead of paying its debt to foreign lenders. That eventually gives rise to a sharper contraction.

Furthermore, international lenders can recognize dilution risks at the onset of a financial crisis, thereby rolling over nominal government debt at a lower price. However, the quantitative analysis reveals that the policymaker is more inclined to raise inflation in that case since bailouts alleviate distortionary costs of inflation. I find that the growing share of debt denominated in DC creates strong incentives to build up higher leverage in pre-crisis, which eventually calls for more massive bailouts and more considerable inflation in a crisis. Hence, the policymaker tends to place more debt denominated in FC to moderate moral hazard issues. I find a more significant correlation coefficient between output and the share of DC debt when bailouts are available. Revealing that anticipated bailouts restrict emerging market governments to place debt in their currencies is a novel contribution of this paper.

Anticipated bailouts create strong incentives to take on more risk ex-ante, which eventually results in a sharper contraction. Thus, the policymaker needs to transfer more resources to the production sector in order to alleviate the drop in asset prices. Given that bailouts are incredibly costly, the policymaker may find it optimal to limit ex-ante borrowing. In line with this perspective, the paper also provides an integrated analysis of capital controls and the currency composition of government debt. I find that capital controls are useful to discipline excessive risk-taking in pre-crisis.

Relation to the Literature. I develop a dynamic stochastic general equilibrium model akin to Bianchi and Mendoza (2018). I suppose that firms are also subject to domestic financial frictions as in Bianchi (2016), unlike that of Bianchi and Mendoza (2018). The binding domestic financial constraint calls for the transfer of resources from households and international lenders to the production sector. Thus, I extend the basic setup by introducing government debt denominated both in FC and DC to study the effects of the fiscal capacity of a government to finance interventions. However, Bianchi (2016); Bianchi and Mendoza (2018) suppose that the government has enough fiscal capacity to finance interventions.

The model is also related to the recent growing literature on the currency composition of government debt. Ottonello and Perez (forthcoming); Du and Schreger (2016) recently study the factors that drive the currency composition of government debt. Also, Engel and Park (2017) solve an optimal contract problem that characterizes state-contingent returns in DC under default as well as dilution risks. These papers define ad-hoc inflation cost functions. However, my setup allows for an endogenous mechanism. In particular, inflationary policies tighten the dividend constraint by distorting labor demand and costing real resources. The policymaker would ultimately dilute the real value of nominal debt by arbitrarily high inflation absent these costs. Thus, the nominal government debt market would shutdown. Unlike these papers, I focus on the effects of the currency composition on ex-ante risk-taking.

The paper also connects with the recent literature that studies trade-offs between the ex-ante excessive build-up of leverage and ex-post financial stability due to bailouts. In particular, Farhi and Tirole (2012) show that bailouts lead to financial fragility, thereby recommending ex-ante regulations to rule them out at equilibrium. Chari and Kehoe (2016) propose that it is optimal to bail out firms to avoid bankruptcy costs. Beside, Keister (2016) shows that commitment to no-bailout policy accelerates bank-runs. Thus, anticipated bailouts are ex-ante efficient. Gertler, Kiyotaki and Queralto (2012); Bianchi (2016) study moral hazard issues under debt and equity financing. However, these papers are silent on the fiscal capacity of a government to finance interventions.

Layout. The next section demonstrates empirical findings. Section 3.2 presents the model economy. Section 3.3 characterizes the inefficiencies in the competitive equilibrium that generate scope for government interventions. Section 3.4 describes time-consistent optimal policies. Section 3.5 presents solution methods, calibration strategies, and main results. Section 3.6 concludes.

3.2 Model

I develop a dynamic stochastic general equilibrium model under nominal and financial frictions. The model economy consists of households, firms, foreign lenders, and a government. Households are the equity owners of firms and supply labor to the production sector, and firms produce in a monopolistic competitive environment by hiring domestic labor and importing inputs from abroad. The policymaker issues bonds denominated both in domestic currency and foreign currency. Besides, the policymaker chooses inflation, collects income taxes from households, and may bail out insolvent firms, and carry out macro-prudential policies.

3.2.1 Households

There exists a continuum of infinitely-lived households with a unit measure that maximizes the lifetime utility:

$$\max_{c_t,h_t} \quad \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} \tag{3.2.1}$$

where $\mathbb{E}$ denotes the conditional expectations operator, c_t shows the domestic consumption of domestically produced final goods, h_t is labor supply. $\beta \in (0,1)$ is the subjective discount factor, $\sigma \geq 0$ shows the coefficient of constant relative risk aversion, χ is the coefficient of labor effort, and ν denotes the inverse Frisch elasticity of labor supply. The utility function is given in the GHH (Greenwood, Hercowitz, and Huffman, 1988) form that eliminates wealth effect on labor supply. Otherwise, the model would fail to produce realistic employment dynamics in a crisis.

Households are the equity holders of firms. I suppose that firms can not raise new equity from households. Thus, the total number of shares is normalized to unity. The representative household's budget constraint in nominal terms is

$$P_t c_t = W_t h_t + P_t d_t$$

where d_t shows dividend payments, P_t is the price index of final domestic goods. W_t denotes nominal wages. Then, the budget constraint in terms of domestic goods is

$$c_t = w_t h_t + d_t \tag{3.2.2}$$

where $w_t = \frac{W_t}{P_t}$ denotes real wages.

3.2.2 Production Sector

A continuum of monopolistic competitive firms operates Cobb-Douglass technology to produce intermediates. Final good producers competitively aggregate differentiated intermediate goods into a consumption composite.

Final Good Producers

Final good producers use Dixit-Stiglitz aggregation technology to produce a composite good y_t from intermediate goods y_{jt}:

$$y_t = \left[\int_0^1 y_{jt}^{\frac{\gamma-1}{\gamma}} dj\right]^{\frac{\gamma}{\gamma-1}}$$

where $\gamma > 1$ shows the elasticity of substitution among different varieties of intermediate goods. Then, the aggregate price index of a composite good is

$$P_t = \left[\int_0^1 P_{jt}^{1-\gamma} dj\right]^{\frac{1}{1-\gamma}}$$

where P_{jt} is the price of a specific variety j.

Cost minimization gives the optimal demand for each variety j:

$$y_{jt} = \left(\frac{P_{jt}}{P_t}\right)^{-\gamma} y_t$$

The following function gives the foreign consumption of final domestic goods:

$$c_t^* = \left(\frac{P_t}{\varepsilon_t P_t^*}\right)^{-\rho} \psi^*$$

where ρ is the elasticity of substitution between imported and domestically produced final goods in the foreign consumption basket. ψ^* is the foreign demand shifter. ε_t shows the nominal exchange rate. P_t^* is the foreign price of final goods normalized to unity hereafter.

Let $e_t = \frac{\varepsilon_t}{P_t}$ denote the real exchange rate, and then foreign demand is

$$c_t^* = e_t^{\rho} \psi^* \tag{3.2.3}$$

Intermediate Goods Producers

A continuum of firms indexed by $j \in [0,1]$ produces a specific variety j in a monopolistic competitive environment. They hire labor h_{jt} and capital k_{jt} and import inputs v_{jt}.

$$y_{jt} = z_t k_{jt}^{\alpha_k} v_{jt}^{\alpha_v} h_{jt}^{\alpha_h} \tag{3.2.4}$$

where z_t shows the total factor productivity that follows a finite-state Markov process. $\alpha_k, \alpha_v, \alpha_h \geq 0$ denote capital, imports and labor shares respectively.

Each firm j pays external debt b_{jt} denominated in FC. They issue bonds b_{jt+1} in FC at an exogenous interest rate r_t in world markets, hire labor h_{jt}, and make dividend payments d_{jt} to households. They can also reset the price of a variety j P_{jt} each period, but resetting the price of a variety is subject to the quadratic adjustment cost that generates price stickiness as in Rotemberg (1982):

$$\frac{a}{2}\left(\frac{P_{jt}}{P_{jt-1}} - \pi^*\right)^2$$

where π^* is the inflation target. a is the adjustment cost parameter. The price adjustment process takes some real resources. Firms take the price of capital Q_t in DC as given. Thus, the budget constraint in nominal terms is

$$\begin{aligned} P_t d_{jt} + \varepsilon_t b_{jt} + Q_t k_{jt+1} = (1+\tau_y) P_{jt} y_{jt} - W_t h_{jt} - \varepsilon_t p_v v_{jt} + \varepsilon_t \frac{b_{jt+1}}{1+r_t} + Q_t k_{jt} \\ - P_t \frac{a}{2}\left(\frac{P_{jt}}{P_{jt-1}} - \pi^*\right)^2 - P_t \tau_y y_t \end{aligned}$$

where p_v is the price of imported inputs in FC, and it is exogenous to the small open economy. The output is subsidized by τ_y to correct distortions due to monopolistic competition. Lump-sum taxes on all firms fund the subsidy. Let $q_t = \frac{Q_t}{P_t}$ denote the real price of capital. Then, the flow budget constraint in terms of domestic goods is

$$\begin{aligned} d_{jt} + e_t b_{jt} + q_t k_{jt+1} = (1+\tau_y)\frac{P_{jt}}{P_t} y_{jt} - w_t h_{jt} - e_t p_v v_{jt} + e_t \frac{b_{jt+1}}{1+r_t} + q_t k_{jt} \\ - \frac{a}{2}\left(\frac{P_{jt}}{P_{jt-1}} - \pi^*\right)^2 - \tau_y y_t \end{aligned} \tag{3.2.5}$$

Firms also borrow intratemporal loans at a zero interest rate to finance a constant fraction of imported inputs in advance. However, total debt is limited not to exceed the stochastic fraction κ_t of expected asset prices. The collateral constraint in terms of domestic goods is

$$e_t \frac{b_{jt+1}}{1+r_t} + e_t \theta p_v v_{jt} \leq e_t \kappa_t \mathbb{E}_t \left\{ \frac{q_{t+1}}{e_{t+1}} k_{jt+1} \right\} \tag{3.2.6}$$

where θ denotes the constant fraction of imported inputs that are financed in advance. Thus, binding external borrowing constraint increases the effective factor costs, thereby reducing the production. Also, it puts downward pressure on current dividend payments and affects expected dividend streams.

Domestic equity market frictions also limit firms' capacity to finance asset purchases. This constraint plays very crucial roles in model dynamics. It is

$$\underline{d} \leq d_{jt} \tag{3.2.7}$$

where $\underline{d}$ shows the lowest bound on dividend payments. I find that the external borrowing constraint first binds. The tight borrowing regime pressures firms to reduce dividend payments to households. However, domestic financial frictions prevent firms from cutting down dividend payments beyond the bound $\underline{d}$. Therefore, firms fire-sell assets to pay their debts and make dividend payments. Therefore, domestic financial frictions lead to very sharp drop in asset prices.

I suppose that firms are identical, thus drop index j and focus on the symmetric recursive equilibrium. Let $s_t \equiv \{z_t, r_t, \kappa_t\}$ and B_t denote exogenous states and aggregate bond holdings, respectively. I suppose that aggregate capital stock is fixed at unity $K_t = 1$. Let $\{k_t, b_t\}$ denote individual states of a firm. Then, aggregate states are given by $S_t \equiv \{s_t, B_t\}$. Households own firms. Thereby firms discount the future by households' stochastic discount factor:

$$m(S_t, S_{t+1}) = \beta \frac{\left(c_{t+1} - \chi \frac{h_{t+1}^{1+\nu}}{1+\nu}\right)^{-\sigma}}{\left(c_t - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{-\sigma}}$$

The representative firm maximizes the discounted value of future dividend payments:

$$\mathbb{E}_t \sum_{k=1}^{\infty} m(S_t, S_{t+k}) d_{t+k} \tag{3.2.8}$$

The following first-order condition to the price of a variety j shows the distortionary costs of inflation on labor demand:

$$(1+\eta_t)\left((\gamma-1)y_t(1+\tau_y) - w_t h_t \frac{\gamma}{\alpha_h} + a\left(\pi_t - \pi\right)\pi_t\right) = \mathbb{E}_t m(S_t, S_{t+1})\left(1+\eta_{t+1}\right)$$
$$a\left(\pi_{t+1} - \pi\right)\pi_{t+1}$$

where η_t is the Lagrange multiplier associated with the dividend constraint. Suppose that nominal frictions disappear $a = 0$, then the condition is given by:

$$\frac{\gamma-1}{\gamma}\alpha_h \frac{y_t}{h_t}(1+\tau_y) = w_t$$

where the left (right) hand side denotes the marginal value (cost) of hiring an additional unit of labor. Thus, the output subsidy given by $\tau_y = \frac{1}{\gamma-1}$ completely corrects monopolistic distortions.

Let W denote the dividend market value of a firm. Then, the optimization problem in the recursive form is

Definition 3.1 (**The Recursive Problem of The Firm**). *The representative firm chooses* *allocations to maximize the shareholder value given government policies, prices, and the output subsidy:*

$$W(k, b, S) = \max_{\Gamma} \{d + \mathbb{E}m(S, S') W(k', b', S')\}$$

where $\Gamma \equiv \{d, h, v, k', b'\}$ *and subject to*

1. *the budget constraint:*

$$d = y - wh - ep_v v - eb + e\frac{b'}{1+r} + qk - qk' - \frac{a}{2}(\pi - \pi^*)^2$$

2. *and the collateral constraint*

$$e\frac{b'}{1+r} + e\theta p_v v \leq \kappa \mathbb{E}\left\{\frac{e}{e'}q'k'\right\}$$

3. *and the dividend constraint*

$$\underline{d} \leq d$$

where $'$ *denotes the future variables.*

3.2.3 Competitive Equilibrium

I focus on the recursive symmetric equilibrium. The aggregate resource constraint of domestic goods can be obtained by combining the household's budget constraint with the firm's budget constraint:

$$c + c^* + eb = y + e\frac{b'}{1+r} - ep_v v - \frac{a}{2}(\pi - \pi^*)^2 \tag{3.2.9}$$

I suppose that inflation equals to the target $\pi = \pi^*$ in the competitive equilibrium.

Definition 3.2 (**The Recursive Competitive Equilibrium**). *Given exogenous states* $s \equiv \{z, r, \kappa\}$*, aggregate states* $S \equiv \{s, B, K\}$*, government policies* $\Omega(S)$ *and the output subsidy*

τ_y, the recursive stationary competitive equilibrium consists of the equity value $W(k, b, S)$, the stochastic discount factor $m(S, S')$, policy functions for households $\hat{c}(S; \Omega(S))$, $\hat{h}(S; \Omega(S))$, policy functions for firms $\hat{d}(S; \Omega(S))$, $\hat{h}(S; \Omega(S))$, $\hat{v}(S; \Omega(S))$, $\hat{b}'(S; \Omega(S))$, $\hat{k}'(S; \Omega(S))$, prices $\hat{q}(S; \Omega(S))$, $\hat{w}(S; \Omega(S))$, $\hat{\eta}(S; \Omega(S))$, $\hat{\mu}(S; \Omega(S))$, $\hat{\pi}(S; \Omega(S))$, $\hat{e}(S; \Omega(S))$ and the law of motion of aggregate variables $S' = \Lambda(S)$ such that

1. *Policy functions $\hat{c}(S; \Omega(S))$, $\hat{h}(S; \Omega(S))$ solve the household's problem given prices and government policies.*

2. *Policy functions $\hat{d}(S; \Omega(S))$, $\hat{h}(S; \Omega(S))$, $\hat{v}(S; \Omega(S))$, $\hat{b}'(S; \Omega(S))$, $\hat{k}'(S; \Omega(S))$ solve the firm's recursive problem given government policies, prices and the output subsidy τ_y.*

3. *Prices clear goods and labor markets. $\hat{\mu}(S; \Omega(S))$ and $\hat{\eta}(S; \Omega(S))$ are the Lagrangian multipliers associated with the collateral and dividend constraints, respectively. The resource constraint Equation 3.2.9 holds.*

4. *The law of motions are consistent with individual states:*

   $$\hat{K}'(S; \Omega(S)) = \hat{k}'(S; \Omega(S)) \quad \textit{and} \quad \hat{B}'(S; \Omega(S)) = \hat{b}'(S; \Omega(S))$$

   and the stochastic processes for z, r, κ.

5. *The representative household's marginal rate of substitution gives the stochastic discount factor.*

3.3 Constrained Efficiency

I first derive inefficiencies in the competitive equilibrium that generates scope for interventions. The social planner maximizes the lifetime utility of households. This problem is subject to competitive equilibrium and resource constraints. I also suppose that goods and labor markets clear competitively. Thus, asset prices and wages are determined competitively, but the planner can recognize how allocations affect them, unlike private agents.

Definition 3.3 (**Constrained Efficiency**). *The planner chooses allocations to maximize the lifetime social utility of the representative household:*

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

where $\Gamma_t \equiv \{c_t, h_t, v_t, q_t, b_{t+1}, \pi_t, e_t\}_{t=0}^{\infty}$ *and subject to*

1. *the resource constraint*

$$c_t + c_t^* + e_t b_t = y_t + e_t \frac{b_{t+1}}{1+r_t} - e_t p_v v_t - \frac{a}{2}\left(\pi_t - \pi^*\right)^2$$

2. *and the collateral constraint*

$$e_t \frac{b_{t+1}}{1+r_t} + e_t \theta p_v v_t \leq \kappa_t \mathbb{E}\left\{\frac{e_t}{e_{t+1}} q_{t+1}\right\}$$

3. *and the dividend constraint*

$$\underline{d} \leq y_t - w_t h_t - e_t p_v v_t + -e_t b_t + e_t \frac{b_{t+1}}{1+r_t} - \frac{a}{2}\left(\pi_t - \pi^*\right)^2$$

4. *and the competitive equilibrium prices* q_t *and* w_t*.*

The optimal monetary policy is inflation stabilization as in the standard New Keynesian models since departing from the target inflation level does not bring about any benefits, but real adjustment costs. Thus, the planner finds it optimal to stabilize inflation.

Corollary 3.1 (**The Optimal Monetary Policy**). *The optimal monetary policy is inflation stabilization:* $\pi_t = \pi^*$*.*

Private agents fail to internalize how borrowing choices affect asset prices, and labor demand affects wages. Prices, in turn, affect the tightness of borrowing and financial constraints.

I compare the competitive equilibrium conditions with the planner's optimal conditions to formally show inefficiencies in the decentralized equilibrium. Let λ_t, μ_t, η_t, and ξ denote the Lagrange multipliers of the resource constraint, the borrowing constraint, the dividend constraint, and asset prices.

Then, the optimality condition of the social planner to b_{t+1} illustrates the pecuniary externality by clarifying the main distinction between the competitive equilibrium and the social planner allocations:

$$b_{t+1} :: \quad \lambda_t \frac{e_t}{1+r_t} - \mu_t \frac{e_t}{1+r_t} + \eta_t \frac{e_t}{1+r_t} + \underbrace{\xi_t \frac{dq_t}{db_{t+1}}}_{Externality} = 0$$

Furthermore, firms can not internalize how their labor demand affects wages that, in turn, affect the tightness of the dividend constraint. The planner recognizes than it can turn wages in favor of firms by lowering labor demand. The following first-order condition to labor formally shows the pecuniary externality:

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

The planner recognizes the effects of labor demand on the tightness of the dividend constraint by $\frac{dw_t}{dh_t} h_t$. The planner realizes that demanding an additional unit of labor reduces profits by $\frac{dw_t}{dh_t} h_t$. Thus, the planner restricts employment to prevent the fire-sale of assets.

These inefficiencies call for interventions. The binding domestic equity constraint prevents the flow of funds from households to firms. The policymaker can impose lump-sum taxes on households to alleviate the fire-sale of assets. By transferring tax revenue to firms, the policymaker can completely overcome this pecuniary inefficiency. However, I suppose that lump-sum taxes to alleviate the fire-sale of assets are infeasible. The following corollary formally connects lump-sum taxes with optimal bailouts:

Corollary 3.2 (**Lump-Sum Taxes and Optimal Bailouts**). *If the policymaker can impose lump-sum taxes on households and tax revenue can be transferred to firms, then the dividend constraint is always slack. Thus, optimal bailouts are* $T_t = \underline{d} - d_t$.

3.4 Time-Consistent Optimal Policies

In this section, I formally define time-consistent policies. In particular, the policymaker chooses policies each period by taking as given the policies of its future-self. I find the fixed point of policies of the current and future policymakers.

Additionally, I study time-consistent policies since the Ramsey optimal policies are time-inconsistent for two reasons. First, while bailouts alleviate the drop in asset prices, they lead to excessive leverage in pre-crisis. Thus, they also need to be restricted to mitigate moral hazard issues. However, the policymaker finds it optimal to bail out the production sector in a crisis. Therefore, promising to eliminate bailouts is not credible when a crisis hits. Second, the policymaker issues bonds denominated in DC. The price of nominal bonds decreases with expected inflation since the policymaker lacks the commitment to its policies. Even if the policymaker promises not to allow for inflationary policies, rational foreign lenders internalize that when debt is issued, this promise is not credible.

Domestic financial frictions prevent the flow of funds from households to firms. I suppose that the policymaker can extract resources from households to alleviate the drop in asset prices. Besides, I also introduce government debt denominated both in DC and FC. Thus, the policymaker can also extract resources from foreign lenders through monetary policy. In particular, an inflation tax can reduce the real value of nominal claims to foreign lenders. I extend the essential setup step by step to study the relative effectiveness of each policy.

3.4.1 Optimal Bailout Policies: Equity Injections

The policymaker can raise asset prices in a crisis by relaxing the dividend constraint. The policymaker is now restricted to collect only income taxes from households to finance equity injections.

Definition 3.4 (**Optimal Time-Consistent Equity Injections**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \{c_t, h_t, v_t, d_t, k_{t+1}, b_{t+1}, e_t, \tau_t, T_t\}$*, where* T_t *shows equity injections financed through income taxes* τ_t*. This problem is subject to the competitive equilibrium conditions:*

1. *but now the household's budget constraint is replaced by*

$$c_t = (1 - \tau_t) w_t h_t + d_t$$

2. *the firm's budget constraint is replaced by*

$$d_t = y_t - w_t h_t - e_t p_v v_t - e_t b_t + e_t \frac{b_{t+1}}{1 + r_t} + q_t k_t - q_t k_{t+1} - \frac{a}{2} (\pi_t - \pi^*)^2 + T_t$$

3. *the government's budget constraint is*

$$T_t = \tau_t w_t h_t$$

4. *the intratemporal labor Euler is replaced by*

$$\chi h_t^{\nu} = (1-\tau_t)w_t$$

5. *perceived policies coincide with actual policies.*

3.4.2 Optimal Bailout Policies: Debt Guarantees

In this section, I suppose that the government pays a fraction of FC liabilities. The policymaker can also finance this policy by imposing income taxes on households.

Definition 3.5 (**Optimal Time-Consistent Debt Guarantees**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \{c_t, h_t, v_t, d_t, k_{t+1}, b_{t+1}, e_t, \tau_t, \psi_t\}$*, where* ψ_t *shows the fraction of debt paid by the government. This problem is subject to the competitive equilibrium conditions:*

1. *but now the household's budget constraint is replaced by:*

$$c_t = (1-\tau_t)w_t h_t + d_t$$

2. *firms' budget constraint given by:*

$$d_t = y_t - w_t h_t - e_t p_v v_t - (1-\psi_t)e_t b_t + e_t \frac{b_{t+1}}{1+r_t} + q_t k_t - q_t k_{t+1} - \frac{a}{2}(\pi_t - \pi^*)^2$$

3. *the government's budget constraint is:*

$$\psi_t e_t b_t = \tau_t w_t h_t$$

4. *the intratemporal labor Euler is:*

$$\chi h_t^{\nu} = (1-\tau_t) w_t$$

5. *perceived policies coincide with actual policies.*

3.4.3 Optimal Equity Injections and Capital Controls

The normative analysis shows that the competitive equilibrium is inefficient for two reasons. First, firms can not recognize that lowering borrowing can raise asset prices. Second, they can not internalize that reducing employment turns wages in favor of their balance sheets. As discussed in the previous section, equity injections alleviate the drop in asset prices, but borrowing also needs to be limited. Thus, I combine equity injections with capital controls in this section.

Definition 3.6 (**Optimal Time-Consistent Equity Injections and Capital Controls**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \{c_t, h_t, v_t, d_t, k_{t+1}, b_{t+1}, e_t, \tau_t, T_t, \tau_t^c\}$*, where* τ_t^c *shows capital inflow taxes. This problem is subject to the competitive equilibrium conditions:*

1. *but now the household's budget constraint is replaced by*

$$c_t = (1-\tau_t) w_t h_t + d_t$$

2. *the firm's budget constraint is replaced by*

$$d_t = y_t - w_t h_t - e_t p_v v_t - e_t b_t + (1-\tau_t^c) e_t \frac{b_{t+1}}{1+r_t} + q_t k_t - q_t k_{t+1} - \frac{a}{2}(\pi_t - \pi^*)^2 + T_t$$

3. *the government's budget constraint is*

$$T_t = \tau_t w_t h_t + \tau_t^c e_t \frac{b_{t+1}}{1+r_t}$$

4. *the intratemporal labor Euler is replaced by*

$$\chi h_t^{\nu} = (1-\tau_t) w_t$$

5. *the Euler equation of b_{t+1} is replaced by*

$$(1+\eta_t)(1-\tau_t^c) = (1+r_t)\beta \mathbb{E}_t m(S_t, S_{t+1})(1+\eta_{t+1}) + \mu_t$$

6. *perceived policies coincide with actual policies.*

3.4.4 Optimal Payroll Taxes and Capital Controls

The normative analysis shows that firms over-demand labor and over-borrow in FC. In this section, I examine how effective are payroll taxes and capital controls in correcting these inefficiencies. I suppose that the policymaker chooses payroll taxes, debt taxes, then transfer tax revenue firms' balance sheets as lump-sum payments.

Definition 3.7 (**Optimal Time-Consistent Payroll Taxes and Capital Controls**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t, h_t, v_t, d_t, k_{t+1}, b_{t+1}, e_t, \tau_t^h, \tau_t^c\right\}$, *where* τ_t^h *shows payroll taxes. This problem is subject to the competitive equilibrium conditions:*

1. *but now the household's budget constraint is replaced by*

$$c_t = (1-\tau_t)w_t h_t + d_t$$

2. *the firm's budget constraint is replaced by*

$$d_t = y_t - w_t h_t - e_t p_v v_t - e_t b_t + (1-\tau_t^c)e_t \frac{b_{t+1}}{1+r_t} + q_t k_t - q_t k_{t+1} - \frac{a}{2}\left(\pi_t - \pi^*\right)^2 + T_t$$

3. *the government's budget constraint is*

$$T_t = \tau_t w_t h_t + \tau_t^c e_t \frac{b_{t+1}}{1+r_t}$$

4. *the intratemporal labor Euler is replaced by*

$$\chi h_t^{\nu} = (1-\tau_t)w_t$$

5. *the Euler equation of b_{t+1} is replaced by*

$$\left(1+\eta_t\right)\left(1-\tau_t^c\right) = (1+r_t)\beta \mathbb{E}_t m(S_t, S_{t+1})\left(1+\eta_{t+1}\right) + \mu_t$$

6. *perceived policies coincide with actual policies.*

3.4.5 Optimal Debt and Inflation

I extend the basic setup by introducing long-term government debt denominated both in FC and DC. Now, the policymaker has access to debt policy and an inflation tax that reduces the real value of its nominal liabilities to foreign lenders together with income taxes.

I follow the sovereign debt literature and model the long-term government debt as a perpetuity contract with coupon payments. In particular, a bond issued in period t promises an infinite stream of coupons that decreases at an exogenous constant rate ζ as in Ottonello and Perez (forthcoming); Hatchondo and Martinez (2009); Arellano and Ramanarayanan

(2012); Chatterjee and Eyigungor (2012). The decay rate ζ also determines the average duration of bonds, and the short term debt corresponds to the particular case $\zeta = 0$. In particular, issuing one unit government debt in DC in period t promises the following cash flows in the next periods $t+1$, $t+2$, ...:

$$\left[1,\ \zeta,\ \zeta^2,\ ...\right]$$

In exchange, the policymaker receives q_t (q_t^*) units in DC (FC) now. The main advantage of this formulation of the long-term debt is that future payments can be condensed into a one-dimensional state variable, the number of coupon payments that mature in the current period.

The policymaker now starts the period with outstanding debt B_{gt} denominated in DC and b_{gt}^* in FC. The policymaker issues debt $\left[b_{gt+1}^* - \zeta b_{gt}^*\right]$ ($[B_{gt+1} - \zeta B_{gt}]$) by taking q_t^* (q_t) as given. If $\left[b_{gt+1}^* - \zeta b_{gt}^*\right] < 0$ ($[B_{gt+1} - \zeta B_{gt}] < 0$), the policymaker repurchases long-term bonds. Otherwise, the policymaker promises to make coupon payments in future periods.

There is a continuum of identical risk-neutral international lenders. They have complete information regarding the economy's fundamentals. Thus, foreign lenders value DC cash flows in FC as follows:

$$\left[\frac{1}{e_{t+1}},\ \frac{\zeta}{e_{t+2}},\ \frac{\zeta^2}{e_{t+3}},\ ...\right]$$

Foreign lenders behave competitively and expect zero profit at equilibrium. They can either invest in the risk-free asset that pays a net real return r^* in FC or government bond denominated in DC. The policymaker can not commit to its future policies and may reduce the real value of its nominal claims to foreign lenders through an inflation tax. Thus, the price of nominal claims depends on the dilution risks at equilibrium. In specific, the equilibrium price of nominal debt decreases with the anticipated dilution risks. In other words, the payoff depends on the expected inflation. The arbitrage condition gives that the expected dilution risk premia are equalized with the return of the risk-free asset. Thus, the price of DC and FC debt given by respectively:

$$q_t = \frac{1}{1+r^*}\mathbb{E}_t\left[\frac{e_t}{e_{t+1}}\left(1+\zeta q_{t+1}\right)\right], \quad q_t^* = \frac{1}{1+r^*-\zeta} \tag{3.4.1}$$

Nominal bonds and the bond price have a stochastic trend. I focus on the stationary equilibrium. Thus, I de-trend these variables by the lag of the aggregate price level P_t. Let $b_{gt} = B_{gt}/P_{t-1}$ denote the de-trended version of the nominal debt.

Definition 3.8 (**Optimal Time-Consistent Debt and Inflation**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

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

where $\Gamma_t \equiv \left\{c_t, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, \pi_t, e_t, b_{gt+1}, b^*_{gt+1}\right\}$ *and subject to the competitive equilibrium conditions:*

1. *but now the household's budget constraint is replaced by*

$$c_t = (1-\tau_t)w_t h_t + d_t$$

2. *the government's budget constraint is*

$$e_t b^*_{gt} + \frac{b_{gt}}{\pi_t} = \tau_t w_t h_t + e_t q^*_t\left(b^*_{gt+1} - \zeta b^*_{gt}\right) + q_t\left(b_{gt+1} - \zeta\frac{b_{gt}}{\pi_t}\right)$$

3. *the market clearing condition for final goods is replaced by*

$$c_t + c^*_t + e_t b_t = y_t + e_t\frac{b_{t+1}}{1+r_t} - e_t p_v v_t - \frac{a}{2}\left(\pi_t - \pi^*\right)^2 - e_t b^*_{gt} - \frac{b_{gt}}{\pi_t} + e_t q^*_t\left(b^*_{gt+1} - \zeta b^*_{gt}\right) + q_t\left(b_{gt+1} - \zeta\frac{b_{gt}}{\pi_t}\right)$$

4. *bond prices are given by Equation 3.4.1.*

The costs of inflation are endogenous in the model.

Proposition 3.1 (**Market Shutdown**). *Absent endogenous costs of inflation $a = 0$, positive nominal debt in the equilibrium can not be sustainable. Thus, the nominal government debt market is shut down.*

Proof. The policymaker lacks a commitment to its policies. Without the costs of inflation, the policymaker finds it optimal to ultimately dilute the real value of its nominal debt to international lenders, but rational foreign lenders predict this incentive and will lend at zero price. □

3.4.6 Optimal Debt, Inflation and Bailouts

The policymaker can now choose bailouts in addition to the policies chosen in the previous section. This exercise reveals the relative effectiveness of bailouts. Besides, it shows how bailouts affect the currency composition of sovereign debt.

Definition 3.9 (**Optimal Time-Consistent Debt, Inflation and Bailouts**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

$$V(S_t) = \max_{\Gamma_t} \{u(c_t, h_t) + \beta \mathbb{E}_t V(S_{t+1})\}$$

where $\Gamma_t \equiv \left\{c_t, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, \pi_t, e_t, \hat{b}_{gt+1}, b^*_{gt+1}\right\}$ *and subject to the competitive equilibrium conditions. The equations in the previous section are adjusted as follows:*

1. *the government's budget constraint is*

$$e_t b^*_{gt} + \frac{b_{gt}}{\pi_t} + T_t = \tau_t w_t h_t + e_t q^*_t \left(b^*_{gt+1} - \zeta b^*_{gt}\right) + q_t \left(b_{gt+1} - \zeta \frac{b_{gt}}{\pi_t}\right)$$

2. *firm's budget constraint given by:*

$$d_t = y_t - w_t h_t - e_t p_v v_t - e_t b_t + e_t \frac{b_{t+1}}{1+r_t} + q_t k_t - q_t k_{t+1} - \frac{a}{2}\left(\pi_t - \pi^*\right)^2 + T_t$$

3. *perceived policies coincide with actual policies.*

3.4.7 Optimal Capital Controls

To show how capital controls affect dilution risks and ex-ante risk-taking, I suppose that the policymaker can also choose debt taxes along with the policies expressed in the previous section. Capital controls limit borrowing, thereby affecting expected bailouts and dilution risks.

Definition 3.10 (**Optimal Time-Consistent Capital Controls**). *The policymaker maximizes the utility of the representative agent at each period, given the perceived policy functions of its future-self.*

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

where $\Gamma_t \equiv \left\{c_t, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, \tau_t^c, \pi_t, e_t, T_t, b_{gt+1}, b^*_{gt+1}\right\}$ *and subject to the competitive equilibrium conditions. The equations in the previous section are changed as follows:*

1. *the government's budget constraint given by:*

$$e_t b^*_{gt} + \frac{b_{gt}}{\pi_t} + T_t = \tau_t w_t h_t + \tau_t^c e_t \frac{b_{t+1}}{1+r_t} + e_t q_t^* \left(b^*_{gt+1} - \zeta b^*_{gt}\right) + q_t \left(b_{gt+1} - \zeta \frac{b_{gt}}{\pi_t}\right)$$

2. *firms' budget constraint given by:*

$$d_t = y_t - w_t h_t - e_t p_v v_t - e_t b_t + (1-\tau_t^c) e_t \frac{b_{t+1}}{1+r_t} + q_t k_t - q_t k_{t+1} - \frac{a}{2}\left(\pi_t - \pi^*\right)^2 + T_t$$

3. *the Euler equation of b_{t+1} given by:*

$$(1+\eta_t)(1-\tau_t^c) = (1+r_t)\beta\mathbb{E}_t m(S_t, S_{t+1})(1+\eta_{t+1}) + \mu_t$$

4. *perceived policies coincide with actual policies.*

3.5 Quantitative Analysis

3.5.1 Solution Method

I solve the model by global solution methods due to the occasionally binding constraints. Policy functions are not differentiable in this model because of occasionally binding constraints. Cubic B-splines approximate functions and their derivatives outside grid points. I solve the competitive equilibrium by policy function iteration and time-consistent policies by value function iteration that is subject to the competitive equilibrium constraints.

3.5.2 Calibration

I compute the country borrowing rate as the sum of the EMBI spread and US T-bill rate. I suppose that the financial shock is exogenous to interest rate and productivity and then estimate transition probabilities by simulation methods.

I calibrate the model to match the key moments of an average emerging economy for the 1980 - 2015 period. Table 3.1 reports parameter values. I choose the standard values for $\sigma, \nu, \alpha_k, \alpha_v, \alpha_h, r^*, \gamma$. χ normalizes employment to unity. Cruces and Trebesch (2013) find that the average duration of bonds in the developing world is four years. Thus, I set ζ to 0.76. I suppose that firms can not issue equity in a crisis and set $\underline{d} = 0$. a matches the standard deviation of inflation. r^* is calibrated to 4%.

3.5.3 Results

Figure 3.1 shows the policy functions of the competitive equilibrium (DE), the social planner's problem (SP), and optimal time-consistent policies (OP) as a function of the current level of private debt absent domestic financial frictions.

The next period of debt choice is strictly increasing with the current level of debt in the high borrowing regime. However, adverse financial shock significantly changes this trend. Imports and labor significantly drop in the tight borrowing regime. However, the social planner internalizes in the inefficiency in the competitive market, thereby reducing borrowing to raise asset prices. Higher asset prices, in turn, relax the borrowing constraint. Thus, the planner can raise imports to produce more. The policymaker under discretion tends to reduce the real value of nominal claims to foreign lenders. The policymaker significantly increases inflation.

Figure 3.2 shows policy functions when both external borrowing and domestic financial frictions exist. The quantitative analysis reveals that the external borrowing constraint first binds, and then the tight borrowing regime presses firms to cut down dividend payments to households. However, domestic financial frictions restrict the drop in dividend payments. Thus, firms fire-sell assets to pay their debts and satisfy dividend payments. However, the policymaker can alleviate the drop by facilitating the transfer of resources from households and international lenders to the production sector.

Table 3.2 shows the correlations between leverage and the currency composition of sovereign debt and leverage in pre-crisis and the scale of bailouts in a crisis. In the benchmark case where the policymaker can not transfer resources to firms' balance sheets. Model - 1 (Model - 2) refers to bailout policies without (with) capital inflow taxes. As the share of the government debt denominated in DC grows, firms accumulate more substantial debt denominated in FC since they expect larger-scale interventions in a crisis. However, when bailouts are supplanted with capital inflow taxes, I find smaller excessive leverage build-up in pre-crisis.

3.6 Conclusion

This paper studies whether the growing share of government debt denominated in DC leads to excessive leverage build-up in pre-crisis that, in turn, how affects the currency composition. First, I find that when the policymaker accumulates larger debt in DC, firms tend to over-borrow that eventually calls for massive scale bailouts in a crisis. Thereby, the policymaker tilts the currency composition to FC to mitigate moral hazard issues.

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C Appendix

C.1 Numerical Algorithm

Competitive Equilibrium

I solve the competitive equilibrium allocations by policy function iteration given government policies $\Omega(S_t)$, where aggregate grid space given as $S_t \equiv \left\{s_t, B_t, B_{gt}, B^*_{gt}\right\}$. I use B-spline interpolation methods to approximate functions outside grid points.

The computational algorithm can be summarized in the following steps:

1. Grid Points:

   First, I generate discrete grids for the aggregate state space: s_t x B_t x B_{gt} x B^*_{gt}.

2. Initial Guesses:

   I determine initial guesses for policy functions as steady-state values and compute expectations using these guesses.

3. Equilibrium Policy Functions:

   I find the competitive equilibrium allocations by policy function iteration as follows:

   (a) Suppose that only the borrowing constraint Equation 3.2.6 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (b) Suppose that only the equity constraint Equation 3.2.7 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (c) Suppose that both collateral and equity constraints bind, then solve for the equilibrium allocations. Check whether constraints bind. If not, continue with the following step.

(d) Suppose that both constraints are slack, then solve for the equilibrium allocations.

4. Expectations:

   I update agents' conditional expectations.

5. Convergence:

   Repeat from item 3 to item 4, until expected values and policy functions converge.

Time-Consistent Optimal Policies

The algorithm searches for time-consistent optimal policies. In other words, the algorithm searches for the fixed points of the policy functions that represent current and future policymakers. Given current and future policymakers' policies, private agents adjust their expectations and find their optimal reactions to the government's policies. Given the agents' expectations and future policies, the current policymaker maximizes the representative agent's welfare. The algorithm stops when current and future policymakers' policies coincide.

I approximate expectations, value functions, and policy functions. The algorithm iterates two loops. The outer loop iterates on expectations, while the inner loop iterates on the value function.

1. Grid Points:

   First, I generate discrete grids for the aggregate state space: s_t x B_t x B_{gt} x B^*_{gt}

2. Initial Guesses:

   I determine initial guesses for policy functions as steady-state values and compute expectations and the value functions using these guesses.

3. Equilibrium Policy Functions:

   I find the competitive equilibrium allocations by policy function iteration as follows:

   (a) Suppose that only the borrowing constraint Equation 3.2.6 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (b) Suppose that only the equity constraint Equation 3.2.7 binds, then solve for the equilibrium allocations. Check whether the constraint binds. If not, continue with the following step.

   (c) Suppose that both collateral and equity constraints bind, then solve for the equilibrium allocations. Check whether constraints bind. If not, continue with the following step.

   (d) Suppose that both constraints are slack, then solve for the equilibrium allocations.

4. Optimal Policies Given The Policy Functions:

   Given the competitive equilibrium policy functions, the policymaker chooses the policies that maximize the welfare at each grid point.

5. Converge of The Value Function:

   Repeat item 4, until the value function converges.

6. Expectations:

   Given the policy functions corresponding to the optimal policies computed in item 5, I update agents' expectations.

7. Convergence:

Repeat from item 3 to item 6, until expectations, the value function and policy functions converge.

C.2 Figures

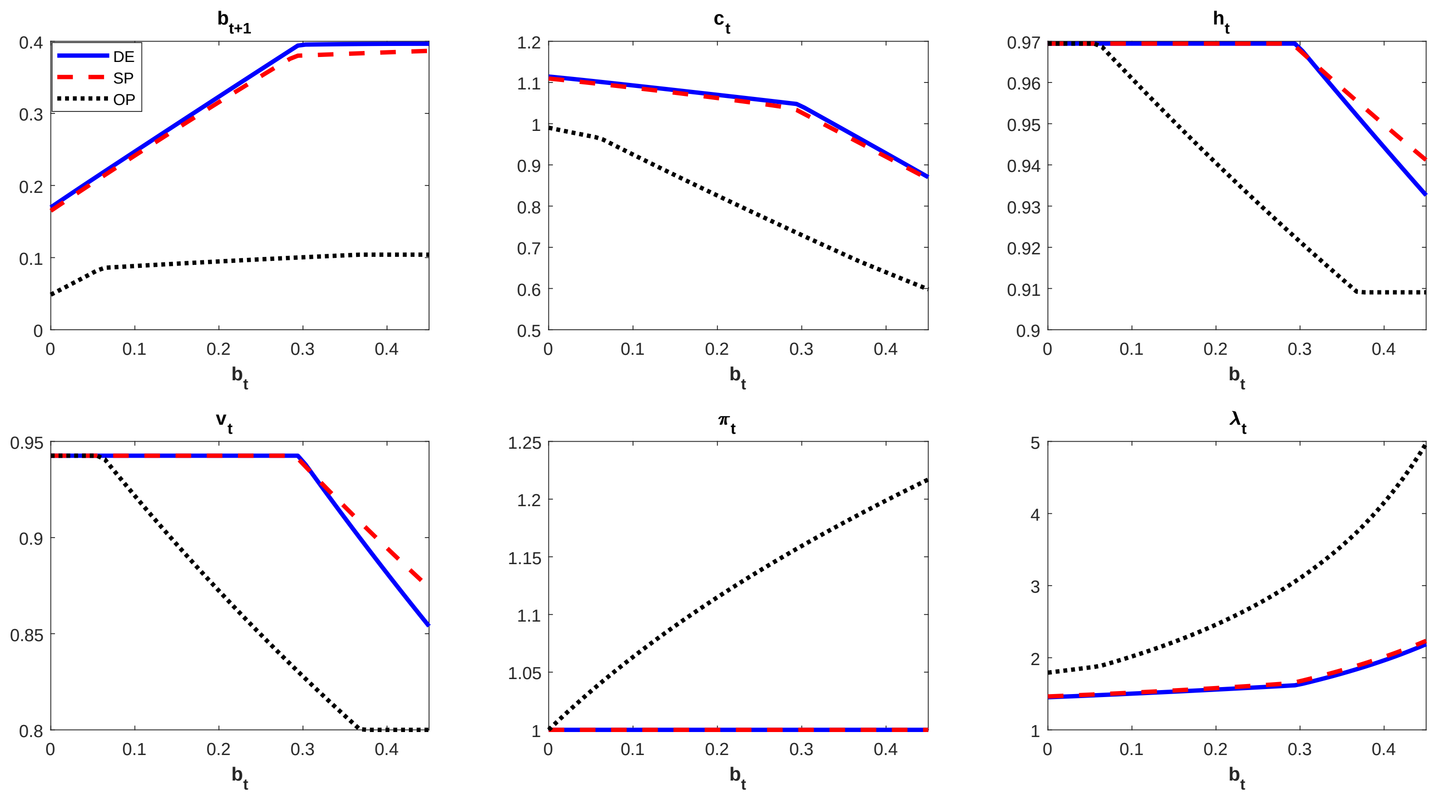

Figure 3.1: Policy functions. DE = Decentralized Equilibrium, SP = Social Planner's Problem, OP = Time-Consistent Optimal Policy.

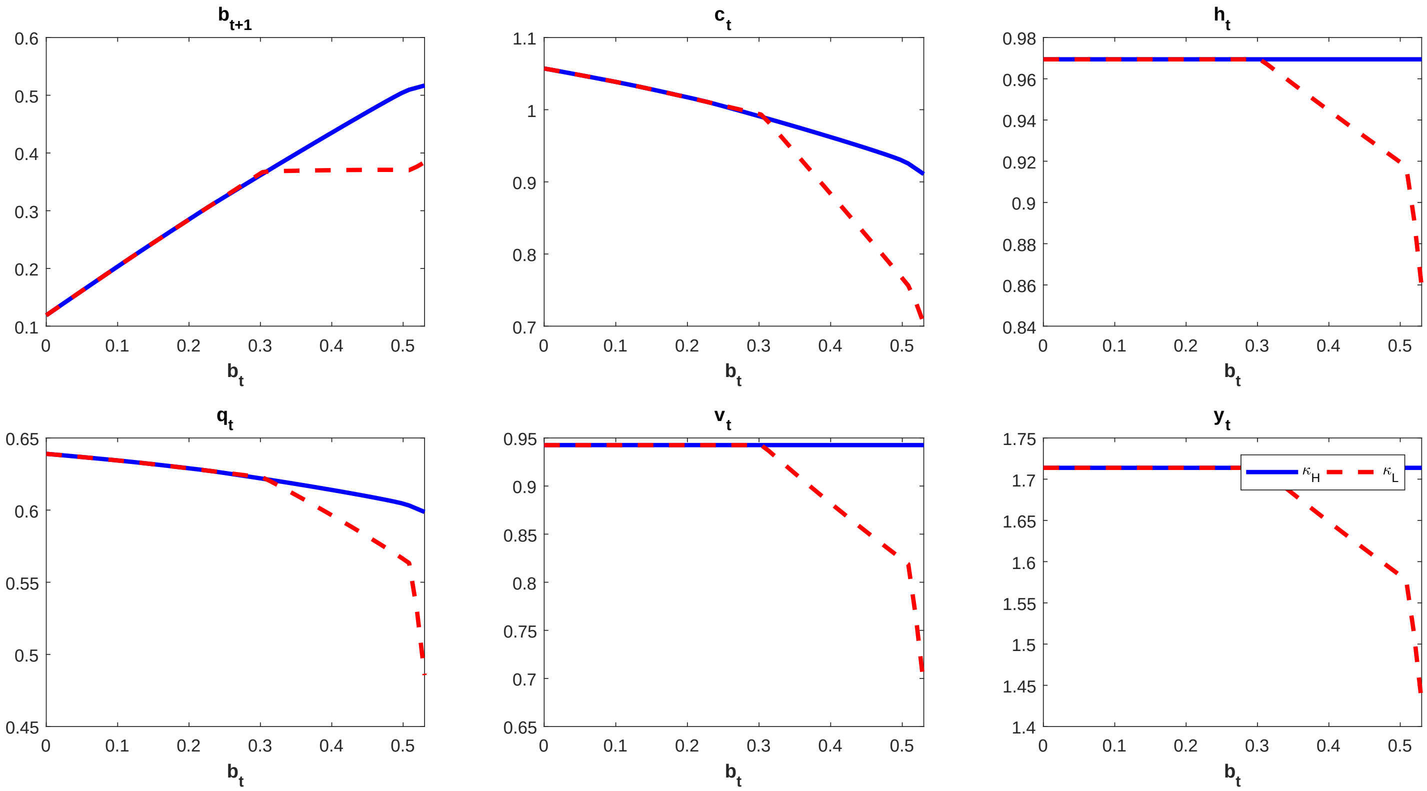

Figure 3.2: Policy functions.

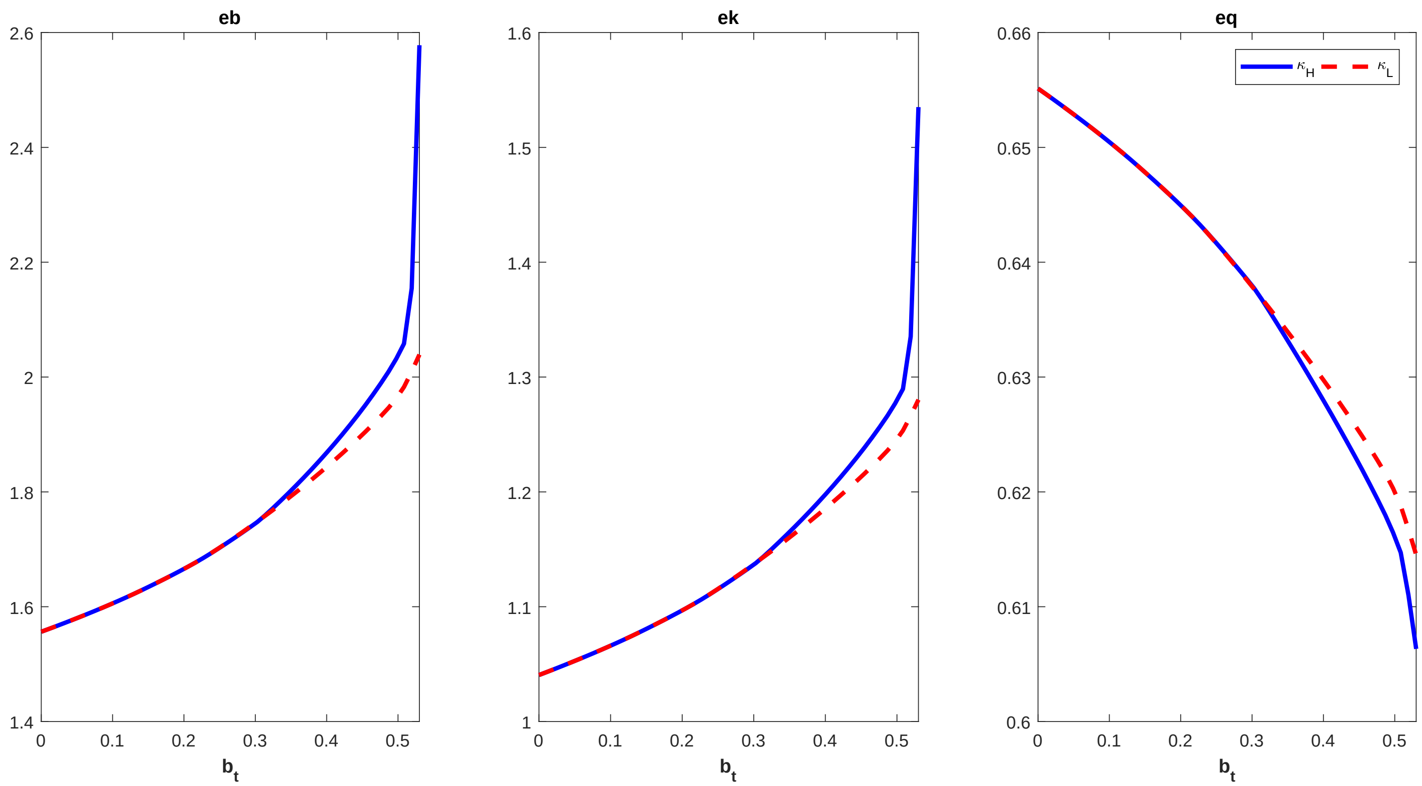

Figure 3.3: Policy functions.

C.3 Tables

Parameter	Description	Value	Target
σ	Risk Aversion	2.00	Standard
β	Discount Factor	0.96	K/Y
α_k	Capital Share	0.08	Bianchi and Mendoza (2018)
α_v	Imports Share	0.45	Bianchi and Mendoza (2018)
α_h	Labor Share	0.35	Bianchi and Mendoza (2018)
χ	Labour Disutility	0.69	$\overline{h} = 1$
ν	Frisch Elasticity	0.50	Fr. Elas.
ζ	Decay Rate	0.76	Avg. Dur.
$\underline{d}$	Equity Threshold	0.00	Standard
a	Price Adjustment Cost	0.40	Std. of π_t
r^*	Risk Free Rate	0.04	Standard
γ	Elasticity of Subs.	3.00	Standard

Table 3.1: Parameters

	Share of DC Debt	Bailouts
Benchmark		
Leverage	0.20	
Model - 1		
Leverage	0.75	0.65
Model - 2		
Leverage	0.45	0.15

Table 3.2: Correlations