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

Salim Ergene *

University of Virginia

October 26, 2019

Abstract

This paper 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, the paper 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 to alleviate the under-capitalization of the production sector, the policymaker is more inclined to impose an inflation tax on international lenders than to collect income taxes from households. Adding the inflation tax as a policy tool significantly raises welfare gains. 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.

Keywords: Bailouts, Time Consistency, Currency Mismatch, Debt Dilution, Capital Controls

*University of Virginia, Department of Economics. e-mail: `se2uz@virginia.edu`.

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 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 take on more risk ex-ante, thereby eventually leading to excessive 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. 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) consistent with the classical empirical findings (Reinhart and Rogoff, 2011).

As emphasized by the related empirical and theoretical literature, fiscal policies are now unable

[1] A bailout package mainly consists of direct equity injections to bank-firms' balance sheet, the purchase of risky financial assets by a government and implicit/explicit guarantees.

[2] Figure 19 shows the average scale of bailouts for some selected emerging market economies.

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

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 classical monetary policy tool such as the 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) and Arslanalp and Tsuda (2014) document that the average DC share of 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 large 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 larger private sector FC liability in pre-crisis is associated with larger 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 can be summarized as when the private sector is exposed to large 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

[4]See the right figure in Figure 19 for the share of DC debt as a percent of the external 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 large 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 large bank bailouts. Russian and Turkish crises have the same pattern.

exposed to large FC debt. However, these predictions are contradicted by the empirical findings in a systemic banking crisis window. Larger 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 important 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 in investment in the tight credit regime, since bank-firms otherwise would fund the desired level of investment by raising 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/or 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-tradables and wage, and that in turn affect the tightness of the 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

[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. Furthermore, 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 currency mismatch between revenues and liabilities.

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. Furthermore, the Ramsey problem 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 solved with value function iteration and the competitive equilibrium allocations obtained with euler equation iteration.[8] To approximate policy functions and value functions outside the grid points, I use B-splines interpolation methods. I 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 to increase 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 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

[8] See Section A.2 for the description of the numerical algorithm.

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-tradables, thereby relaxing the domestic financial constraint. I suppose that the policymaker chooses aggregate spending, then it is allocated to non-tradables 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, while it leads to a higher relative price of non-tradables. In other words, government expenditure results in a smaller rise in output.

These exercises show that bailouts and government expenditure financed through only fiscal policies are unable to fully maintain financial stability. 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 inflationary policies, 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 and 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 partially 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 significantly 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, larger 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 ease 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 connects with several strands of the macro-finance literature. First, it builds on the literature related to the credit channel and the financial accelerator mechanism.[9] 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, the recent studies, pioneered by Gertler and Karadi (2011), provide that a central bank credit policy rule moderates contractions. This literature focuses on log-linear dynamics around a deterministic steady state in which constraints are always binding 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) and Devereux, Young and Yu (forthcoming).

Second, Perez (2015); Sosa-Padilla (forthcoming) and Balke (2016) study the negative feedback loop between the government and banks. They indicate that the sovereign default results in negative 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 large FC liability in a contraction calls for larger 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

[9] 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).

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 endogenously 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 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) contribute that bailouts deepen financial fragility and recommend ex-ante regulation to rule out them in equilibrium. However, Keister (2016) provides that commitment to no-bailout policy accelerates bank-runs and argue 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. Furthermore, Bianchi (2016) contributes 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.

Finally, the paper also builds upon the classical monetary policy literature with financial constraints.[10] In recent works, Ottonello (2015); Schmitt-Grohe and Uribe (2016) and 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

[10]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.

policy should be supplanted by capital controls to mitigate the effects of volatile capital flows. In particular, Bianchi and Mendoza (2018) and Devereux, Young and Yu (forthcoming) quantify 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 larger scale bailouts, the policymaker finds it optimal to restrict ex-ante FC borrowing to discipline the inflationary policies of its future-self.

Layout. Section 2 introduces the model economy. Section 3 characterizes inefficiencies in the competitive equilibrium that justify a scope for government interventions. Section 4 describes time-consistent optimal policies. Section 5 explains solution methods, calibration strategies, and shows the main results. Section 6 introduces some extensions such as inflation-linked debt, financial repression, and risk-averse pricing of nominal debt. Section 7 shows welfare gains corresponding to each policy. Section 8 illustrates the empirical findings. Section 9 concludes.

2 The Model Economy

I develop a dynamic stochastic general equilibrium small open economy model akin to Bianchi (2016). 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. They are also bank-firms' shareholders. Bank-firms operate in the non-tradable sector,[11] 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

[11] 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.

income taxes from households, may bailout bank-firms and carry out macro-prudential policies to mitigate the moral hazard issues of bailouts.

2.1 Households

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

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

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 tradables c_t^T and non-tradables c_t^N:

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

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 wealth effect on labor supply. Otherwise, these models would fail to produce realistic employment dynamics in crisis times.[12]

Each period households receive tradable endowments y_t^T that follows a finite-state, stationary Markov process.[13] 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 given by:

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

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 tradables P_t^{T*} is normalized to unity. The law of one price holds for

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

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

tradables:

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

where e_t shows the nominal exchange rate. Then, the budget constraint in terms of the price of tradable goods can be written by:

$$c_t^T + p_t^N c_t^N = y_t^T + w_t h_t + d_t \tag{2}$$

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 wage in terms of tradable goods.

Then, the intratemporal consumption Euler gives the relative price:

$$p_t^N = \frac{1-a}{a} \left(\frac{c_t^T}{c_t^N} \right)^{\frac{1}{\xi}} \tag{3}$$

2.2 The Production/Non-Tradable Sector

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

2.2.1 Final Goods Producers

The intermediate goods y_{jt}^N's 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 given by:

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

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

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

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

2.2.2 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 by Cobb-Douglas technology in a monopolistic competitive environment:

$$y_{jt}^N = z k_{jt}^{\alpha_k} v_{jt}^{\alpha_v} h_{jt}^{\alpha_h} \tag{4}$$

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.

A 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,[14] invests in 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_{jt}^N each period. The price adjustment problem is subject to the quadratic cost as in Rotemberg (1982):

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

where $\overline{\pi}^N$ is the inflation target in the non-tradable sector, a_p is the price adjustment cost parameter. This adjustment cost plays a key role in the model by generating price stickiness, currency mismatch and inefficient wedge for labor demand.

Thus, the flow budget constraint of a bank-firm j in terms of tradables for each period is given by:

$$d_{jt} + b_{jt} + i_{jt} = (1+\tau_y)\frac{P_{jt}^N}{P_t^T} y_{jt}^N - w_t h_{jt} - p_v v_{jt} + \frac{b_{jt+1}}{1+r_t} - \frac{a_p}{2}\left(\frac{P_{jt}^N}{P_{jt-1}^N} - \overline{\pi}^N\right)^2 - \tau_y p_t^N y_t^N \tag{5}$$

where p_v is the price of intermediate inputs in terms of tradables 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.[15]

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

[15] Alternatively, the production subsidy could also be financed by distortionary taxation. That wouldn't change the main results of the paper. 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 key model dynamics, it significantly improves the quantitative performance of the model by generating investment volatility similar to its counterpart in the data. In addition, it increases the real costs of disinvestment in a crisis. Then, capital accumulation technology is given by:

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

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.[16] The collateral constraint given by[17]

$$\frac{b_{jt+1}}{1+r_t} + \theta p_v v_{jt} \leq \kappa_t k_{jt+1} \tag{6}$$

where θ denotes the fraction of imported inputs financed in advance. The working capital loans assumption is consistent with the empirical evidence which documents that about 40% of such loans are secured with collateral.[18] 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. This 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 κ can also produce realistic crisis dynamics, but 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;

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

[17] 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 type of working capital constraint generates empirically relevant import-to-GDP ratio.

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

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 the financial shock κ_t and the world interest rate r_t 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:

$$\underline{d} \leq d_{jt} \tag{7}$$

here $\underline{d}$ measures the degree of equity market frictions.[19] 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, a policymaker may facilitate the flow of funds from households to bank-firms' balance sheets to recapitalize the production sector. Hence, this constraint plays a key 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. Larger FC debt together with the tight domestic equity constraint calls for larger scale bailouts.

I focus on the symmetric recursive equilibrium, thus drop index j. Let $s \equiv \{y^T, r, \kappa\}$ show

[19] See Bianchi (2016) for the discussion of the empirical relevance of this assumption.

the exogenous states, B and K the economy's aggregate bond and capital positions respectively. Thus, the state variables of a bank-firm are the individual states $\{b, k\}$ and the aggregate states $S \equiv \{s, B, K\}$. Bank-firms maximize their shareholders' value. They discount the future by households' stochastic discount factor $m(S, S')$.[20]

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

Definition 1 (**The Recursive Problem of Bank-Firms**). *The representative bank-firm chooses allocations to maximize the shareholder value given prices and the output subsidy:*

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

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

1. *the budget constraint:*

$$d = p^N y^N - wh - p_v v + (1-\delta)k - k' - \frac{a_k}{2}\left(\frac{k'}{k} - 1\right)^2 k - b + \frac{b'}{1+r} - \frac{a_p}{2}\left(\pi^N - \overline{\pi}^N\right)^2$$

2. *and the collateral constraint:*

$$\frac{b'}{1+r} + \theta p_v v \leq \kappa k'$$

3. *and the dividend constraint:*

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

where $'$ *denotes the future variables.*

2.3 The Recursive 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

[20] The discount factor given by: $m(S_t, S_{t+1}) = \dfrac{\beta\left(c_{t+1} - \chi\frac{h_{t+1}^{1+\nu}}{1+\nu}\right)^{-\sigma}\left[a\left(c_{t+1}^T\right)^{1-\frac{1}{\xi}} + (1-a)\left(c_{t+1}^N\right)^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}-1} a\left(c_{t+1}^T\right)^{-\frac{1}{\xi}}}{\left(c_{t+1} - \chi\frac{h_{t+1}^{1+\nu}}{1+\nu}\right)^{-\sigma}\left[a\left(c_t^T\right)^{1-\frac{1}{\xi}} + (1-a)\left(c_t^N\right)^{1-\frac{1}{\xi}}\right]^{\frac{1}{1-\frac{1}{\xi}}-1} a\left(c_t^T\right)^{-\frac{1}{\xi}}}$

constraint gives rise to the aggregate resource constraint for tradable goods:

$$c^T + b + k' = y^T + \frac{b'}{1+r} + (1-\delta)k - p_v v - \frac{a_k}{2}\left(\frac{k'}{k} - 1\right)^2 k - \frac{a_p}{2}\left(\pi^N - \overline{\pi}^N\right)^2 \tag{8}$$

Non-tradable goods are only consumed domestically. The resource constraint given by:

$$y^N = c^N \tag{9}$$

I suppose that inflation rate in the non-tradable sector is equal to $\overline{\pi}^N$ in the competitive equilibrium, since departing from the inflation stabilization policy does not bring about any benefits in this framework, but convex adjustment costs.[21]

The competitive equilibrium defined by:

Definition 2 (**The Recursive Competitive Equilibrium**). *Given the exogenous state vector* $s \equiv \{y^T, r, \kappa\}$*, the aggregate state vector* $S \equiv \{s, B, K\}$*, the 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* $\left\{\hat{c}(S;\Omega(S)), \hat{c}^T(S;\Omega(S)), \hat{c}^N(S;\Omega(S)), \hat{h}(S;\Omega(S))\right\}$*, policy functions for bank-firms* $\left\{\hat{d}(S;\Omega(S)), \hat{h}(S;\Omega(S)), \hat{v}(S;\Omega(S)), \hat{b}'(S;\Omega(S)), \hat{k}'(S;\Omega(S))\right\}$*, prices* $\left\{\hat{p}^N(S;\Omega(S)), \hat{w}(S;\Omega(S)), \hat{\eta}(S;\Omega(S)), \hat{\mu}(S;\Omega(S)), \hat{\pi}^N(S;\Omega(S))\right\}$ *and the law of motion of the aggregate variables* $S' = \Lambda(S)$ *such that*

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

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

3. *Prices clear goods and labor markets.* $\hat{\mu}(S;\Omega(S))$ *and* $\hat{\eta}(S;\Omega(S))$ *satisfy the collateral and dividend constraints respectively. The resource constraints Equation 8 and Equation 9 both hold.*

[21] Inflation could also be a function of the deviation of the non-tradable output from its steady-state level. This extension would not affect the role of the domestic equity market friction and the main model dynamics.

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 y^T, r, κ.

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

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 δ and capital share α_k, capital return is high enough to fund investment in the deterministic steady state. The dividend constraint is slack. 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.

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-tradables and wage given in the competitive equilibrium.[22] 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 constraint efficient allocations can be reduced to the following problem:

Definition 3 (**Constrained Efficiency**). *The planner chooses allocations to maximize the lifetime social utility of the representative household:*

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

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

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:*

1. *the tradable resource constraint:*

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

2. *and the non-tradable resource constraint:*

$$c_t^N = y_t^N$$

3. *and the collateral constraint is:*

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

4. *and the dividend constraint is:*

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

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

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

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 wage affect the tightness of the dividend constraint. It also distorts capital accumulation. Consequently, the planner builds up capital buffers in normal 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-tradables and the dividend constraint. Let's suppose that the policy functions are differentiable. Then, the optimality condition of the social planner with respect to c_t^N illustrates the pecuniary externality. It clarifies the main distinctions between the competitive equilibrium and social planner allocations:

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

where $\mathbb{C}_t$ denotes the inverse of the derivative of the aggregate consumption with respect 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-tradables 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's why they remain under-capitalized during a crisis. The externality formally given by the following first order condition with respect to h_t:

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

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 raises wages by $\frac{dw_t}{dh_t}$ and reduces 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 above-mentioned externalities bring about market failure. However, they justify interven-

tions 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 political 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 3.2 (**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 given by:* $T_t = \underline{d} - d_t$.

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

Proof. The Langrange multiplier of the dividend constraint (7) is zero ($\eta_t = 0$), when $\underline{d} = -\infty$. Under inflation stabilization, the competitive equilibrium and the planner allocations coincide. □

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's options are restricted to impose only income taxes on households to finance bailouts and government expenditure. Then, the model extended by introducing government debt denominated in DC.[23] In this case, the planner has access to inflation and debt policies. Given that bank-firms are exposed to large 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.

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. The formal definition is given by:

Definition 4 (**Optimal Time Consistent Equity Injections**). *The policymaker chooses equity injections T_t financed by income taxes τ_t. The policymaker maximizes the utility of the representative*

[23] 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. Therefore, as long as the debt issued in DC, the planner would have the incentives to dilute the real value of debt repayment. 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.

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 $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, T_t\right\}$ *and subject to the competitive equilibrium conditions:*

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:*

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

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

$$T_t = \tau_t w_t h_t$$

4. *the intratemporal labor Euler is:*

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

5. *perceived policies coincide with actual policies.*

4.2 Optimal Bailout Policies: Debt Guarantees

Now, I suppose that the policymaker can pay a fraction of FC liabilities. This policy is also financed by income taxes. The formal definition is given by:

Definition 5 (Optimal Time Consistent Debt Guarantees). *The policymaker chooses the fraction of debt payments* ψ_t *financed by income taxes* τ_t*. 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 $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, \psi_t\right\}$ *and subject to the competitive equilibrium conditions:*

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:*

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

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

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

4. *the intratemporal labor Euler is:*

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

5. *perceived policies coincide with actual policies.*

4.3 Optimal Price Support

The policymaker can also increase government expenditure to support the relative price of non-tradables. I suppose that the policymaker chooses aggregate government expenditure, then it is allocated to tradables and non-tradables in fixed proportion to moderate computational costs:

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

Then, the price of government expenditure is given by:

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

The policymaker is again restricted to fund government expenditure by income taxes. The optimal policy can be formally defined by:

Definition 6 (**Optimal Time Consistent Price Support Policies**). *The policymaker chooses government expenditure g_t financed by income taxes τ_t. 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 $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, g_t\right\}$ *and subject to the competitive equilibrium conditions:*

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 of non-tradables is replaced by:*

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

4. *the intratemporal labor Euler is:*

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

5. *perceived policies coincide with actual policies.*

To see the impact of an increase in government expenditure in the relative price of non-tradables, plug in the market clearing in non-tradables into Equation 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.

4.4 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. Therefore, I examine the effects of capital controls on ex-ante risk-taking. The formal definition is given by:

Definition 7 (**Optimal Time Consistent Equity Injections and Capital Controls**). *The policymaker chooses capital controls* τ_t^c *and equity injections* T_t *financed by income taxes* τ_t*. 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 $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, T_t, \tau_t^c\right\}$ *and subject to the competitive equilibrium conditions:*

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:*

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

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:*

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

5. *the Euler equation of* b_{t+1} *given by:*

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

6. *perceived policies coincide with actual policies.*

4.5 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 how effective are payroll taxes to correct this inefficiency. I suppose that the policymaker chooses payroll taxes, then tax revenue is transferred to bank-firms' balance sheets as lump-sum payments.

The optimal policy can be formally defined by:

Definition 8 (Optimal Time Consistent Payroll Tax Policies). *The policymaker chooses payroll taxes τ_t^h. 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 $\Gamma_t \equiv \left\{c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t^h\right\}$ and subject to the competitive equilibrium conditions:

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

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

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

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

3. *perceived policies coincide with actual policies.*

4.6 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 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, 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. The short term debt corresponds to the special case $\zeta = 0$. The maturity increases with ζ. 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 units in DC now. The main advantage of this formulation of the long-term debt is that the future payments can be condensed into a one-dimensional state variable, the quantity of coupon payments that mature in the current period.

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.

There is a continuum of identical risk-neutral international lenders.[24] They have perfect 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 debt given by:

$$q_t = \frac{1}{1+r^*}\mathbb{E}_t\left[\frac{e_t}{e_{t+1}}\left(1+\zeta q_{t+1}\right)\right] \tag{10}$$

Besides, the price of DC debt can be expressed in FC as follows:

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

[24] I also consider the case where the debt is priced by risk-averse foreign lenders.

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 international risk free rate is given as $r_t^c - r^*$.

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.[25] Let $\hat{x}_t = x_t/P_{t-1}$ denote the de-trended version of a variable x.

The nominal exchange rate can be expressed as a function of consumption allocations and inflation. Then, let $\mathcal{E}\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)$ denote the inverse of the nominal exchange rate. [26]

The formal definition of the policymaker's problem is given by:

Definition 9 (**Optimal Time Consistent Debt and Inflation**). *The policymaker chooses government debt denominated in DC b_{gt+1} and inflation in the non-tradable sector π_t^N in addition to government expenditure and income taxes. The policymaker maximizes the utility of the representative agent at each period given the perceived policy functions of its future-self:*

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

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

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

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

[25] The aggregate price index P_t solves the following problem:

$$P_t \equiv \min_{c_t^T, c_t^N} \left\{P_t^T c_t^T + P_t^N c_t^N\right\} \quad s.t. \quad c_t = 1$$

[26] The aggregate inflation can be expressed as a function of the relative price of non-tradables and the non-tradable inflation:

$$\pi\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right) = \pi_t^N \left(\frac{a\left(\frac{1}{p_t^N}\right)^{1-\xi} + 1 - a}{a\left(\frac{1}{p_{t-1}^N}\right)^{1-\xi} + 1 - a}\right)^{\frac{1}{1-\xi}}$$

given p_{t-1}^N and the inverse nominal exchange rate can be written as:

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

2. *the government's budget constraint given by:*

$$p_t^g g_t + \mathcal{E}\left(\pi_t, \frac{c_t^T}{c_t^N}\right)\hat{b}_{gt} = \tau_t w_t h_t + \hat{q}_t\left(\hat{b}_{gt+1} - \zeta\frac{\hat{b}_{gt}}{\pi\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)}\right)$$

3. *the market clearing condition for tradables is replaced by*

$$c_t^T + b_t + \mathcal{E}\left(\pi_t, \frac{c_t^T}{c_t^N}\right)\hat{b}_{gt} + k_{t+1} = y_t^T + \frac{b_{t+1}}{1+r_t} + \hat{q}_t\left(\hat{b}_{gt+1} - \zeta\frac{\hat{b}_{gt}}{\pi\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)}\right)$$
$$+(1-\delta)k_t - p_v v_t - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - \frac{a_p}{2}\left(\pi_t^N - \pi^N\right)^2$$

4. *the market clearing condition of non-tradables is replaced by:*

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

5. *the DC bond price given by Equation 10.*

The costs of inflation are endogenous in the model.

Proposition 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 completely dilute the real value of its debt to international lenders, but rational foreign lenders predict this incentive and will lend at zero price. □

4.7 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. In addition, it shows how bailouts affect the incentives to reduce the real value of outstanding obligations to foreign lenders.

The formal definition of the policymaker's problem is given by:

Definition 10 (**Optimal Time Consistent Debt, Inflation and Bailouts**). *The policymaker chooses bailouts, government debt denominated in DC, inflation in the non-tradable sector, government expenditure and income taxes. The policymaker maximizes the utility of the representative agent at each period given the perceived policy functions of its future-self:*

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

where $\Gamma_t \equiv \left\{ c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, g_t, \pi_t^N, T_t, b_{gt+1} \right\}$ *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:*

$$p_t^g g_t + T_t + \mathcal{E}\left(\pi_t, \frac{c_t^T}{c_t^N}\right) \hat{b}_{gt} = \tau_t w_t h_t + \hat{q}_t \left(\hat{b}_{gt+1} - \zeta \frac{\hat{b}_{gt}}{\pi\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)} \right)$$

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

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

4.8 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.

The formal definition of the policymaker's problem is given by:

Definition 11 (**Optimal Time Consistent Capital Controls**). *The policymaker chooses bailouts, government debt denominated in DC, inflation in the non-tradable sector, government expenditure, capital controls and income taxes. The policymaker maximizes the utility of the representative agent at each period given the perceived policy functions of its future-self:*

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

where $\Gamma_t \equiv \left\{ c_t^T, c_t^N, h_t, v_t, d_t, k_{t+1}, b_{t+1}, \tau_t, \tau_t^c, g_t, \pi_t^N, T_t, b_{gt+1} \right\}$ *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:*

$$p_t^g g_t + T_t + \mathcal{E}\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)\hat{b}_{gt} = \tau_t w_t h_t + \tau_t^c \frac{b_{t+1}}{1+r_t} + \hat{q}_t\left(\hat{b}_{gt+1} - \zeta \frac{\hat{b}_{gt}}{\pi\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)}\right)$$

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

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

3. *the Euler equation of b_{t+1} given by:*

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

5 Quantitative Analysis

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). Policy functions and their derivatives are approximated by cubic B-splines outside the grid points.

5.2 Calibration

There are three exogenous states $\left(y_t^T, r_t, \kappa_t\right)$. The interest rate is computed as the sum 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 with 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.[27]

I calibrate the model to match the key moments of an average economy from 1980 through 2015. Parameter values are reported in Table 3. I use the standard values $\sigma, \nu, \alpha_k, \alpha_v, \alpha_h, r^*, \gamma$. I 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-tradables. Cruces and Trebesch (2013) document that the average duration of bonds in emerging market is four years. Thus, 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 sdandard deviation of the non-tradable inflation.[28] r^* is calibrated to 4%. The share of non-tradables in government expenditure is set to 0.90. I do not have data for the share of non-tradables in government expenditure. Thus, I solve the model with different values to show its effects on model dynamics and check the robustness of results.

5.3 Results

5.3.1 The Competitive Equilibrium

I first consider the case where domestic equity constraint is always slack. Second, I solve the model with domestic financial frictions. These exercises illustrate why equity constraint calls for interventions.

Figure 2 shows the equilibrium policy functions for the next period debt and the next period capital as a function of the current level of debt. I fix the tradable endowment and the interest rate at their mean values. The dashed blue and black lines plot the law of motions in the high borrowing regime. 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

[27] See subsection A.3 for the estimated probabilities.

[28] 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.

of debt as investment cut down in the tight credit regime since bank-firms can not finance the desired level of investment.

The right figure shows capital accumulation. It is strictly decreasing with the current level of debt 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. Thus, lower resources are allocated to investment.

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 3 shows the ergodic distributions of the next period debt and capital in both cases. I simulate the model 100,000 times 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. This reflects 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 as shown in Figure 2. 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. Thus, bank-firms tend to adjust debt.

5.3.2 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-tradables and wage, which in turn affects the tightness of the dividend constraint.

Figure 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, wage decreases more sharply when dividend constraint binds in the planner's problem. Furthermore, the relative price of non-tradables 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-tradables as given in Equation 3. The social planner internalizes pecuniary inefficiencies, thereby restricting employment and the consumption of non-tradables. By doing so, the planner turns prices in favor of the production sector.

5.3.3 Optimal Time Consistent Policies

I first solve the models in which I suppose that 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 6 shows the law of motions for next period debt and capital, and employment, non-tradable output, wage and the relative price of non-tradables as a function of the current level of debt. I fix capital stock, tradable endowment and interest rate at their mean values. OP(T_t) and OP(g_t) denote optimal bailouts and the price support policy respectively. 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. Government expenditure is also financed by only income taxes. 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-tradables 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-tradables but also wage in favor of bank-firms.

I fix the income tax rate at 0.15 and suppose that tax revenue is transferred to bank-firms' balance sheets as bailout payments 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 effective in turning wages and the relative price of non-tradables in favor of bank-firms. In other words, the policymaker accelerates the transfer of resources from wage payments to investment by allowing higher income taxes in optimal policies than the fixed tax rate.

Figure 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. I 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 spline interpolation and then compute 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. While distortionary costs of the price support policy are smaller, 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 8 shows the event window of a crisis. To construct the window, I simulate the variables for 50,000 periods. I 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 strong moral hazard issues. Anticipated bailouts build up higher leverage in pre-crisis that eventually brings about more severe contractions. Bailouts financed by fixed income taxes also lead to higher leverage in pre-crisis than the price support policy does.

I also consider the case where the policymaker can restrict external borrowing to alleviate moral hazard issues. Figure 10 shows policy functions that correspond to an environment in which the policymaker can impose debt tax on bank-firms together with bailouts. Interventions are still financed through income taxes. I find that debt taxes are about 0.17% in this framework. They are only positive at the onset of a crisis. Therefore, policy functions look very similar. Figure 11 shows the limiting distributions of next period debt and capital. The distribution of debt in a model with capital controls is on the left of distribution with only bailouts.

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 echo that the available set of instruments is important 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 fully maintain financial stability since it is very costly to increase income taxes when the marginal utility of consumption is very high. The policymaker finds it optimal to raise income taxes by 40% in the above analysis, but 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 12 shows the exchange rate in three different cases. The exchange rate increases with the current debt level under inflation stabilization since intratemporal consumption allocations affect the relative price of non-tradables. When the policymaker chooses inflation, I find stronger depreciation. However, when bailouts are available, the domestic currency further depreciates in contrast with the predictions of the classical currency mismatch literature.

Figure 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 fully 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 larger depreciation compared to the model without bailouts. Rational international lenders anticipate the incentives and buy bonds at a lower price. In addition, dilution risks are increasing with government debt, thereby the price of nominal bonds is strictly decreasing with government debt.

6 Extensions

6.1 Inflation Linked Debt

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

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

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

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

International lenders expect zero profit at the equilibrium. Then, 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.

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 large set of parameter values, capital return is higher than nominal 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 of the growing share of the government debt in bank-firms' balance sheets in many countries.

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

$$d_t = p_t^N y_t^N - w_t h_t - p_v v_t + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t - b_t + \frac{b_{t+1}}{1+r_t} - \frac{a_p}{2}\left(\pi_t^N - \overline{\pi}^N\right)^2$$
$$\mathcal{E}\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)\varpi\hat{b}_{gt} + \hat{q}_t\varpi\left(\hat{b}_{gt+1} - \zeta\frac{\hat{b}_{gt}}{\pi\left(\pi_t^N, \frac{c_t^T}{c_t^N}\right)}\right)$$

In this framework, incentives to lower 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. In other words, an inflation tax not only extracts resources from foreign lenders to transfer them bank-firms but also tightens the dividend constraint. I find the benefits of bailouts are smaller when a fraction of nominal debt is placed on bank-firms' balance sheets.

6.3 The Risk Averse Pricing of Government Debt

Before, I assume that foreign lenders are risk-neutral. I now relax this assumption. Thus, I follow the sovereign debt literature and introduce an endogenous risk premium. The pricing kernel of international lenders is then given by:

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

where ϱ shows the sensitivity of the lenders' pricing kernel to the exogenous states s_{t+1}.

I find that when nominal debt is priced by risk-averse foreign lender, welfare gains are smaller.

6.4 Ad hoc Bailouts

I conjecture a bailout policy rule such as $T_t = \varsigma \eta_t$, for a constant ς. The scale of bailouts depends on the severity of a crisis. I compare this ad-hoc rule with optimal policies. I find that optimal policies are more effective in accelerating the recapitalization of the production sector.

7 Welfare Analysis

I compute welfare gains to compare the relative effectiveness of each optimal policy. Welfare gains are reported as a percent increase in aggregate consumption. In other words, it is the percent change in aggregate consumption needed to make households indifferent between the optimal policy regime and the competitive equilibrium. Formally, it can be written as:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(c_t(1+\rho) - \chi \frac{h_t^{1+\nu}}{1+\nu}\right)^{1-\sigma}}{1-\sigma} \tag{11}$$

where ρ shows welfare gains as percent of c_t. In other words, it is the required consumption level to make households indifferent between the competitive equilibrium and each optimal policy.

Figure 14 shows the welfare gains when bailouts and government expenditure financed through only income taxes. Bailouts allow for higher welfare gains than the price support policy and the competitive equilibrium with fixed tax rate do. Panel B denotes the welfare gains when interventions can also be financed through an inflation tax. I find higher welfare gains when bailouts are financed by both fiscal and monetary policies.

Figure 15 shows the welfare gains of extensions. I find that welfare gains reduce significantly when nominal debt is priced by risk-averse international lenders (Risk-averse). When nominal debt payoffs are linked to inflation (Inflation), welfare gains are smaller than that of bailouts. Furthermore, if a fraction of nominal debt held by bank-firms (Repression), the policymaker finds it optimal to carry out more conservative inflationary policies.

8 Empirical Evidence

This section documents evidences related to a banking crisis, FC liability and government policies in emerging economies. I use annual data covering the period 1980-2015 for twenty two

emerging market economies.[29] 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.

In Figure 18, the five-years event window centered at date 0 shows the cross-country medians of the cyclical components.[30] The main characteristic of a banking crisis is a large deviation of a macro variable from its trend. In particular, a banking crisis is preceded by several years of expansion. However, a crisis leads to a sudden reversal.

The event window documents a strong DC depreciation in a crisis and the currency starts to recover its losses very gradually. The depreciation rate is measured as the log difference of the nominal exchange rate between the period $t-1$ and t. Tax revenue negatively deviates from the trend that may undermine the fiscal capacity of a government to finance bailouts. The government debt climbs rapidly above the trend when a crisis hits.

Table 1 shows 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) in average are positively (negatively) correlated with the lag of FC liability. Larger pre-crisis FC liability corresponds to larger depreciation and inflation in crisis times despite their currency mismatch effects.

Table 2 reports the regression results corresponding to the log of bailouts as percent of financial assets and the lag of the FC liability for the whole sample. Each observation is a crisis.[31] Bailouts during a crisis are significantly driven by the pre-crisis FC liability. This conclusion is found to be 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. Foreign reserves could be possibly used 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

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

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

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

during a crisis.

The empirical analysis documents a 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 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 excessively depreciate domestic currency to dilute debt. The following sections present the theoretical framework and study the trade-offs associated to the use of exchange rate policy for financial stability.

9 Conclusion

This paper studies the optimal way to finance bailouts in the emergency need of large resources to recapitalize the production sector. While bailouts funded only through income taxes also alleviate the under-capitalization in the production sector, I find it is optimal to support fiscal policy with monetary to finance them since monetary policy can also extract resource from international lenders.

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A Appendix

A.1 The 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 important to find out the feasible debt space for any given capital stock, since the numerical algorithm searches for equilibrium allocations within the feasible 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 $b_f(k)$ as a function of capital stock:

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

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 3 and Equation 4 respectively.

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

$$\frac{\chi h^\nu_t}{c_1(c^T_t, c^N_t)} = \frac{\alpha_h(\gamma - 1)p^N_t y^N_t (1 + \tau_y)}{\gamma h_t}$$

and

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

Market clearing conditions for tradable and non-tradable goods are given by:

$$c^T_t = y^T_{tmin} - p_v v_t - b_{ft}(k_t) + \frac{b_{t+1}}{1 + r_{tmax}} + (1-\delta)k_t - k_{t+1} - \frac{a_k}{2}\left(\frac{k_{t+1}}{k_t} - 1\right)^2 k_t$$

and

$$c^N_t = y^N_t$$

The feasible set is defined:

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

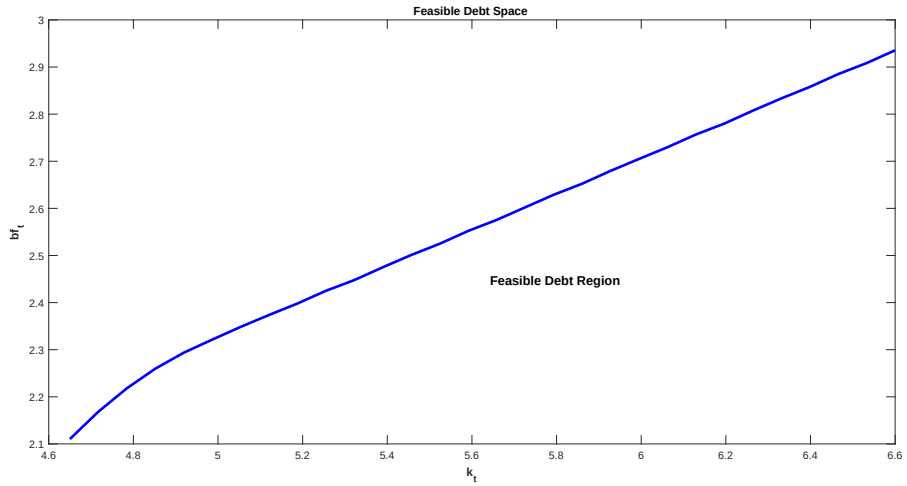

Figure 1: The feasible debt space.

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 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.

A.2 The Numerical Algorithm

A.2.1 The Competitive Equilibrium

I solve the competitive equilibrium allocations by policy function iteration given government policies $\Omega(S_t)$, where aggregate grid space given as $S_t \equiv \{s_t, B_t, K_t\}$. 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

2. Compute The Feasible Debt Space:

   The maximum debt the economy can sustain is computed given government policies and capital stock K_t as in the subsection A.1.

3. Compute Initial Guesses:

   Initial guesses for expectations are determined.

4. Find The Equilibrium Policy Functions:

   The set of policy functions of the competitive equilibrium as functions of the government policies are obtained:
   $\{\mathbb{C}(\Omega_t), \mathbb{C}^T(\Omega_t), \mathbb{C}^N(\Omega_t), \mathbb{Y}^N(\Omega_t), \mathbb{H}(\Omega_t), \mathbb{K}(\Omega_t), \mathbb{B}(\Omega_t), \mathbb{D}(\Omega_t), \mathbb{W}(\Omega_t), \mathbb{P}^N(\Omega_t), \mathbb{V}(\Omega_t)\}$ by guessing that

   (a) First, suppose that only the borrowing constraint Equation 6 binds, then solve for the equilibrium allocations. Check whether the constraint binds, if not move continue with the following step.

   (b) Second, suppose that only the dividend constraint Equation 7 binds, then solve for the equilibrium allocations. Check whether the constraint binds, if not continue with the following step.

   (c) Third, suppose that both the collateral Equation 6 and the dividend constraint Equation 7 bind, then solve for the equilibrium allocations. Check whether constraints bind, if not continue with the following step.

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

5. Update Expectations:

   Given the equilibrium policy functions, agents' conditional expectations are updated.

6. Check Convergence:

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

A.2.2 Time Consistent Optimal Policies

The planner maximizes the representative household's value function V_t and is subject to the competitive equilibrium and the implementability constraints. The government's problem is solved with value function iteration.

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, 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 policymaker's value function. The steps are given by:

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. Compute The Feasible Debt Space:

   The maximum debt the economy can sustain is computed given government policies and capital stock K_t as in the subsection A.1.

3. Compute Initial Guesses:

   Initial guesses for expectations and value functions are determined.

4. Find The Equilibrium Policy Functions Given Government Policies:

   The set of policy functions of the competitive equilibrium as functions of the government policies are obtained:
   $\{\mathbb{C}(\Omega_t), \mathbb{C}^T(\Omega_t), \mathbb{C}^N(\Omega_t), \mathbb{Y}^N(\Omega_t), \mathbb{H}(\Omega_t), \mathbb{K}(\Omega_t), \mathbb{B}(\Omega_t), \mathbb{D}(\Omega_t), \mathbb{W}(\Omega_t), \mathbb{P}^N(\Omega_t), \mathbb{V}(\Omega_t)\}$ by guessing that

   (a) First, suppose that only the borrowing constraint Equation 6 binds, then solve for the equilibrium allocations. Check whether the constraint binds, if not continue with the following step.

(b) Second, suppose that only the dividend constraint Equation 7 binds, then solve for the equilibrium allocations. Check whether the constraint binds, if not continue with the following step.

(c) Third, suppose that both the collateral Equation 6 and the dividend constraint Equation 7 bind, then solve for the equilibrium allocations. Check whether constraints bind, if not continue with the following step.

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

5. Compute Optimal Policies Given The Policy Functions:

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

6. Check Converge of The Value Function:

   Repeat item 5 until the value function converges.

7. Update Agents' Expectations:

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

8. Check Convergence:

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

A.3 Transition Matrix

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

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

A.4 Figures

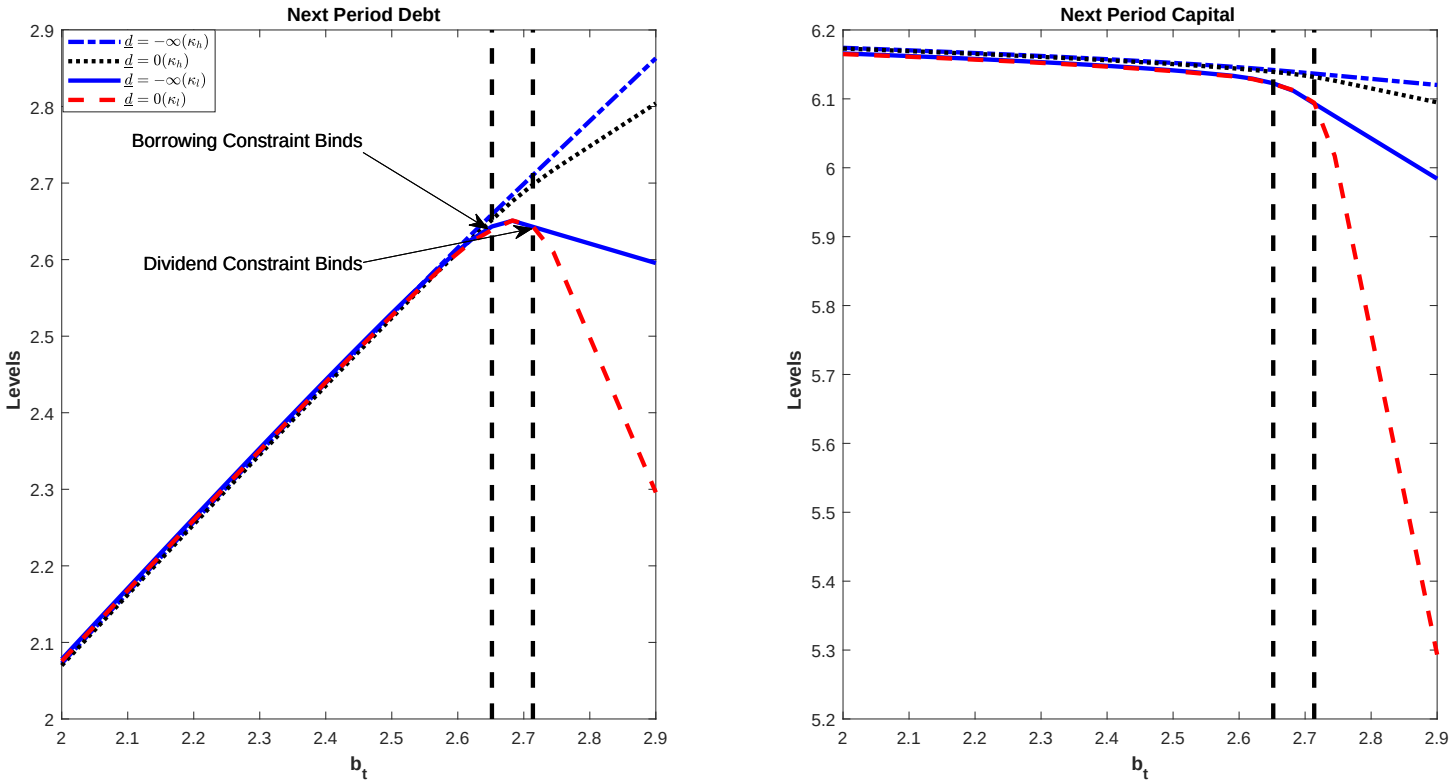

Figure 2: The dashed blue (black) line shows the policy functions without (with) domestic equity market constraints. They also show the high borrowing regime κ_h. The solid blue and dashed red lines denote policy functions in the low borrowing regime κ_l.

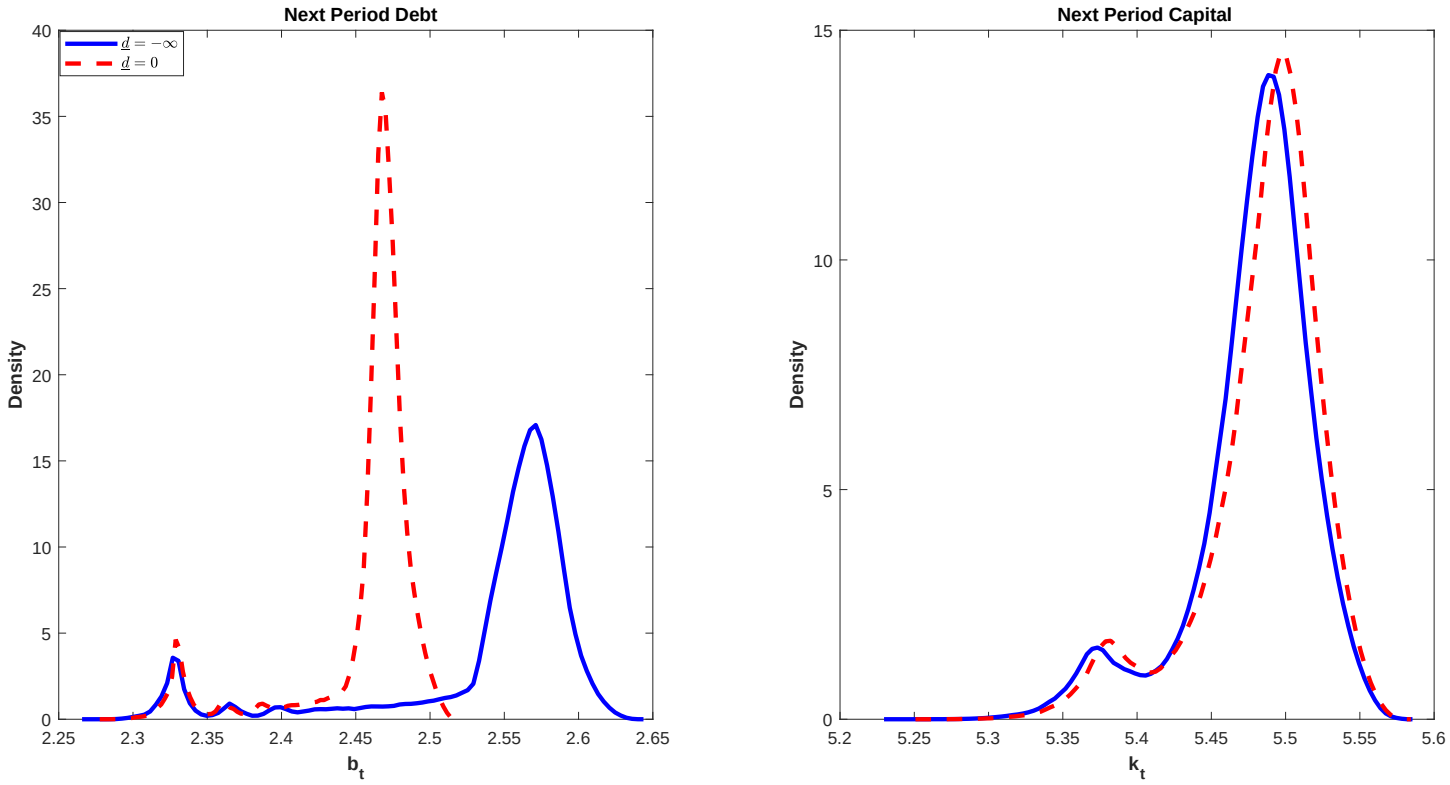

Figure 3: Limiting Distributions.

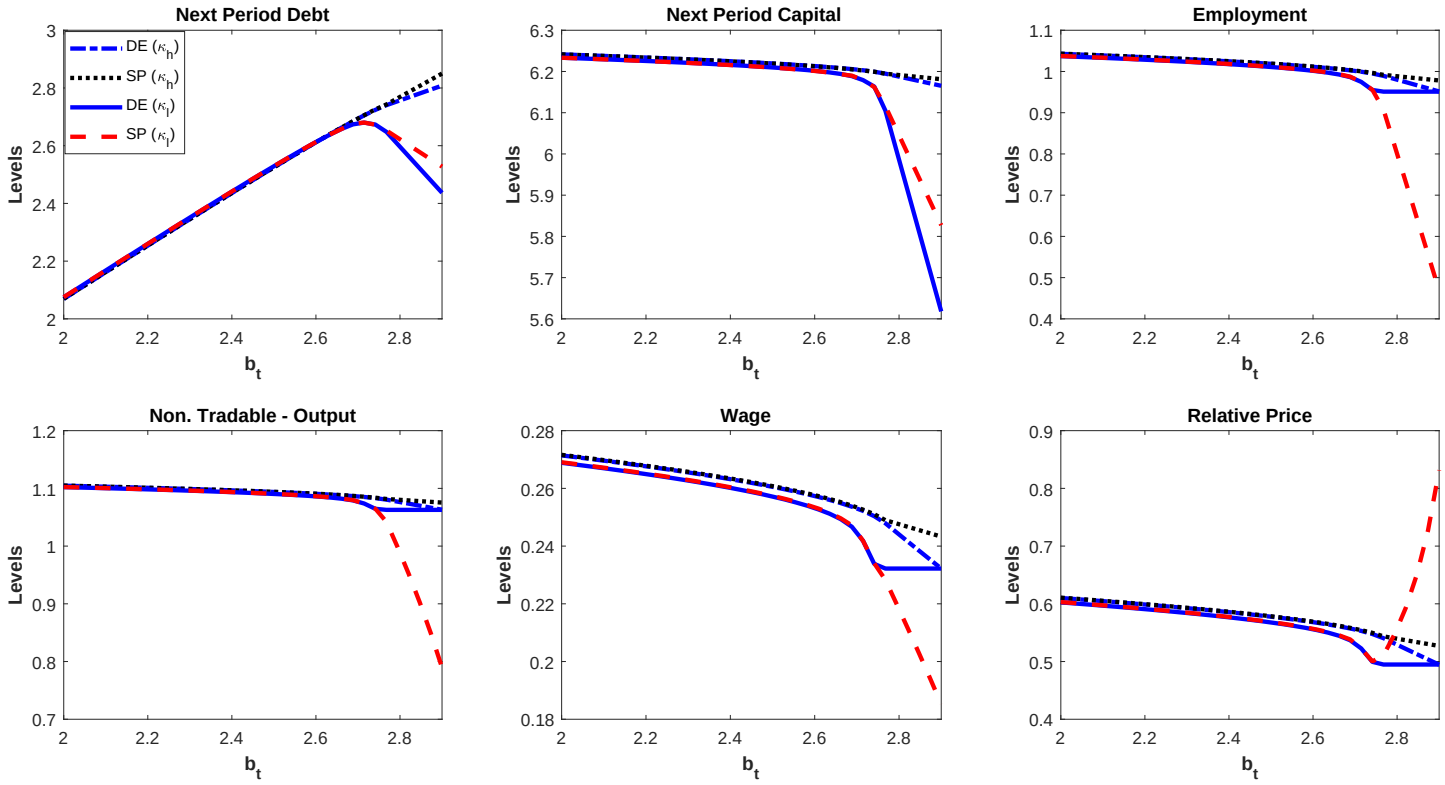

Figure 4: The dashed blue (black) line shows the policy functions of the decentralized equilibrium (social planner) in the high borrowing regime κ_h. The solid blue and dashed red lines denote policy functions in the low borrowing regime κ_l.

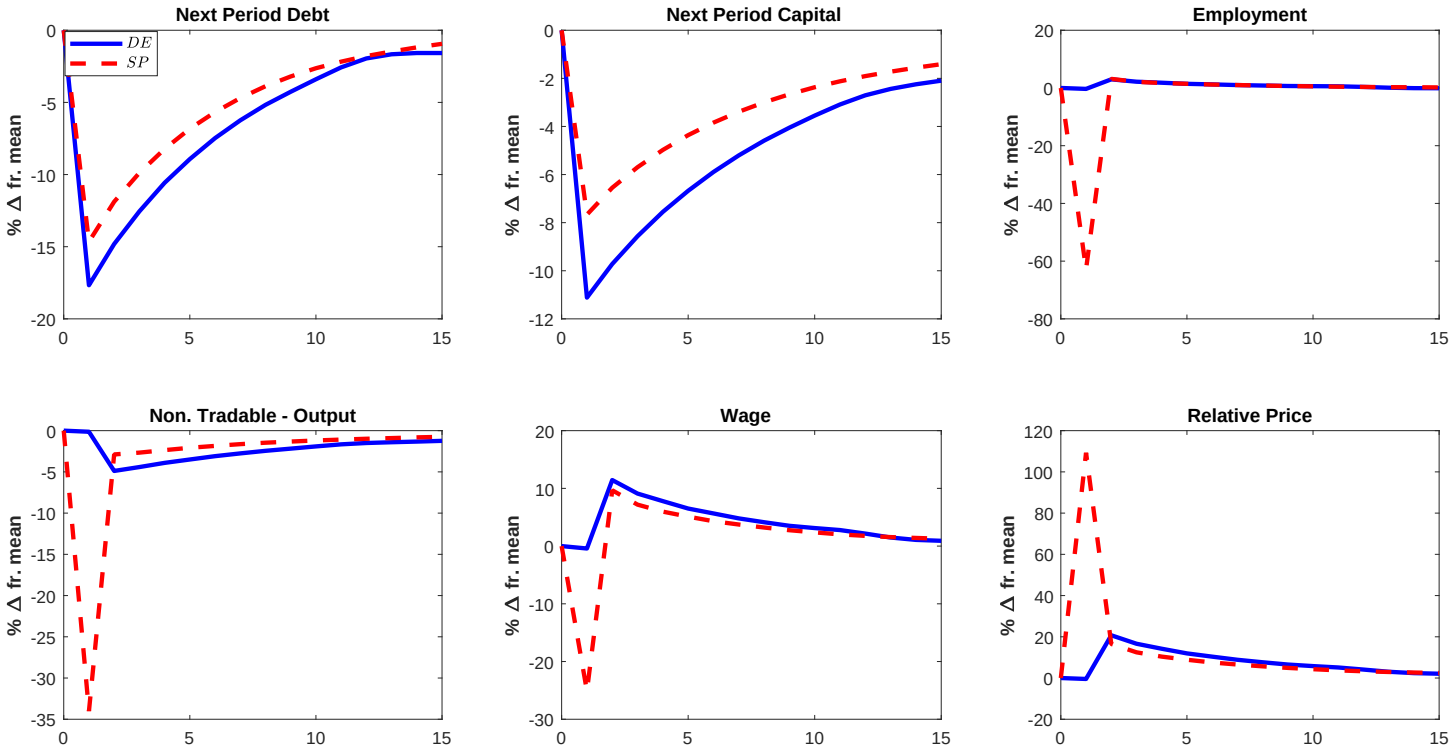

Figure 5: The non-linear impulse response functions to a negative financial shock. The solid (dashed) line shows the impulse response functions of the decentralized equilibrium (the social planner).

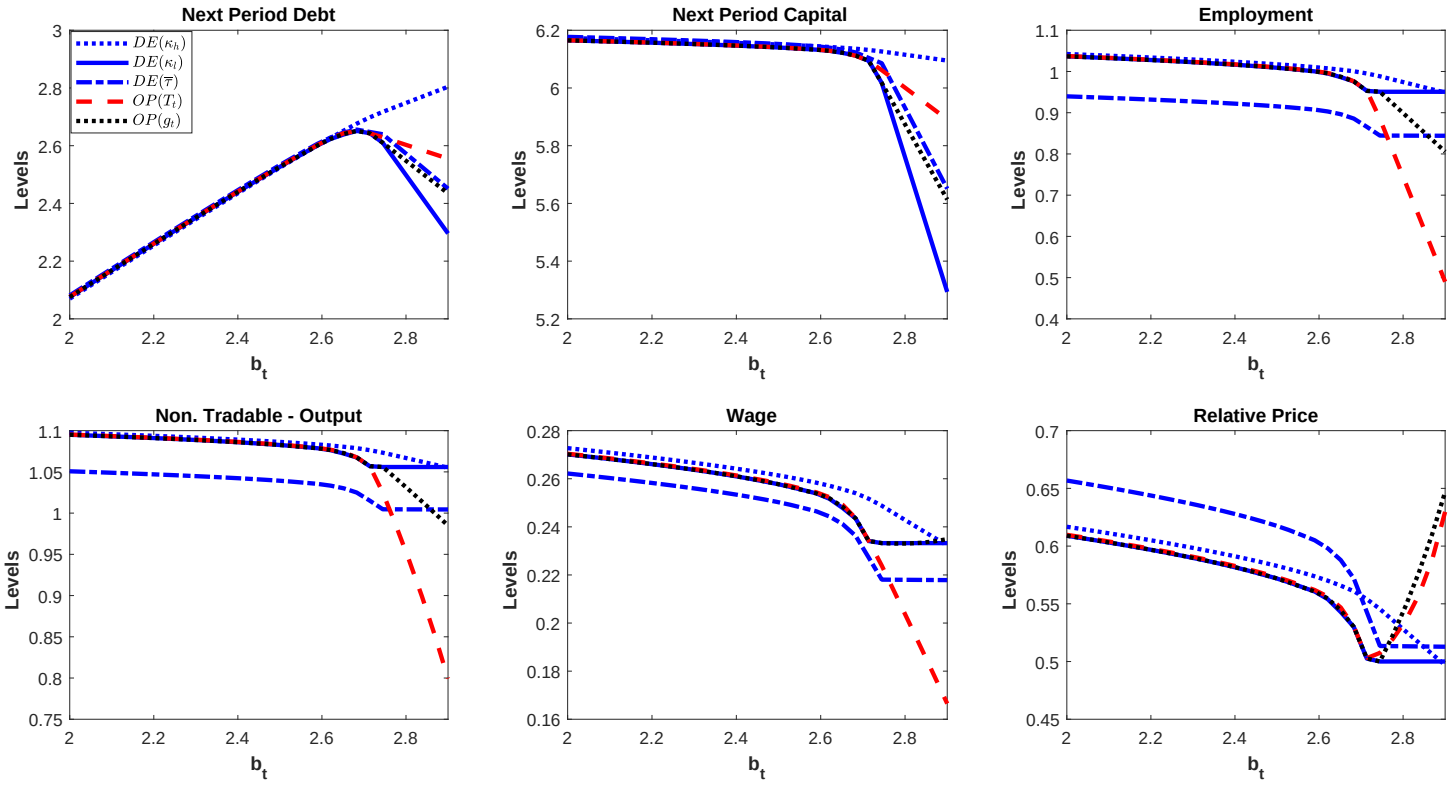

Figure 6: The dashed (solid) blue line shows the policy functions when constraints are slack κ_h (binding κ_l). The dashed red and black lines show the laws of motions with bailouts and price support policies under the tight borrowing regime respectively.

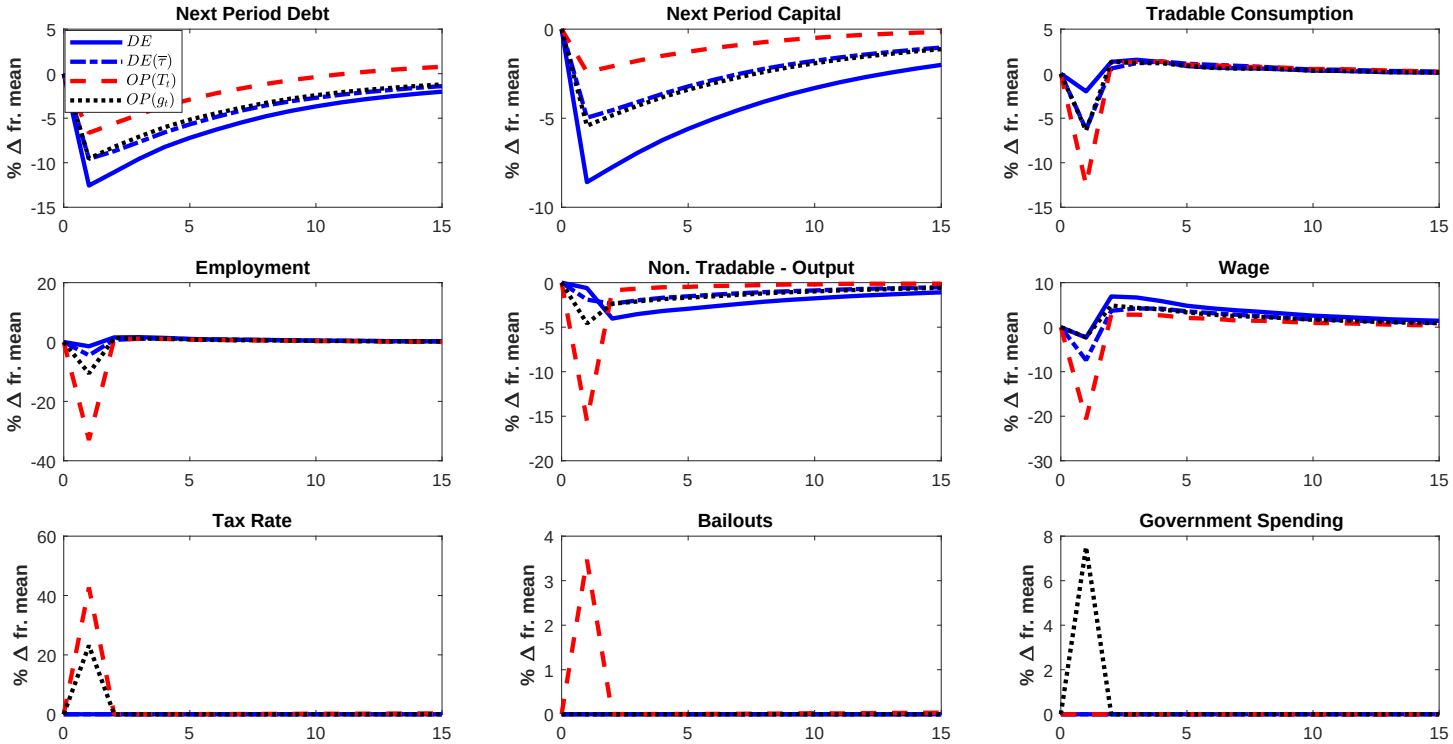

Figure 7: The non-linear impulse response functions to a negative financial shock. The solid (dashed) line shows the impulse response functions of the benchmark model (bailouts and price support models).

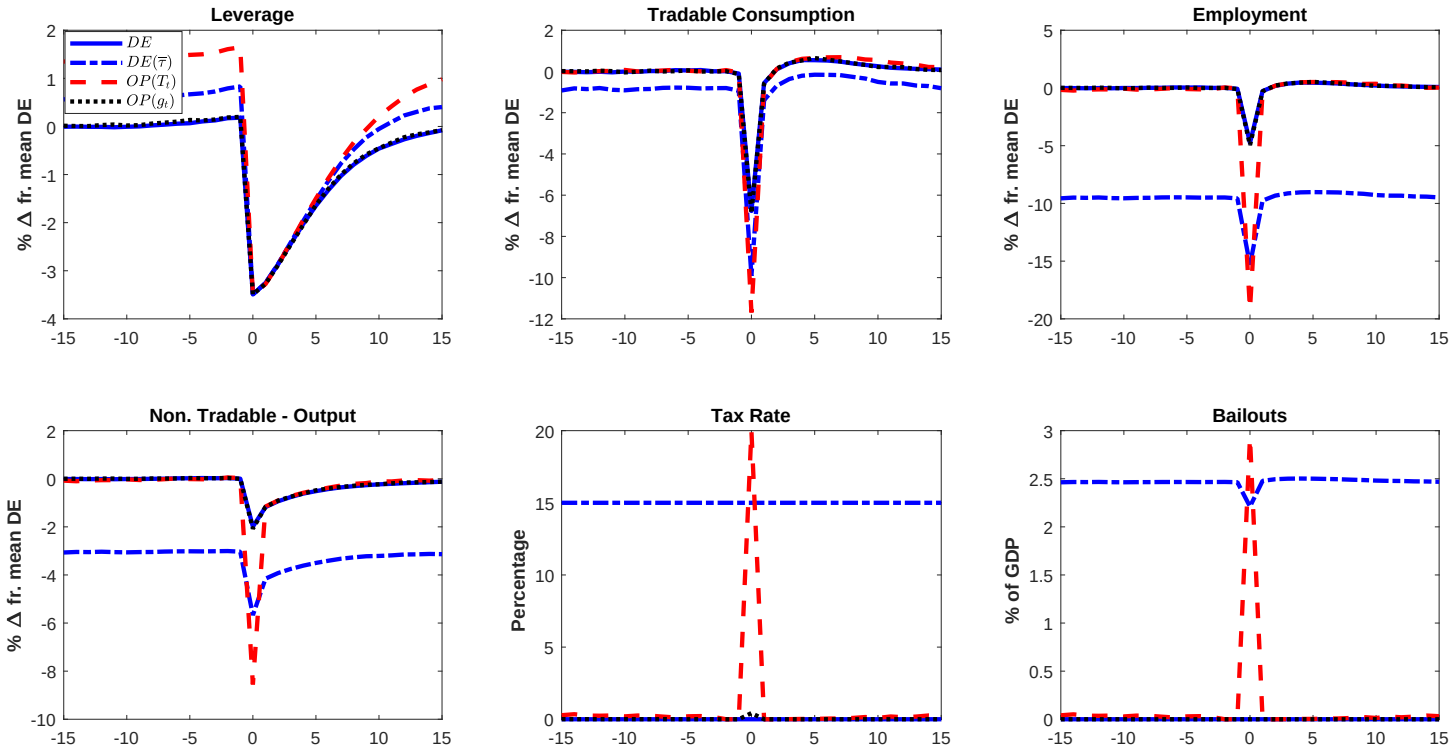

Figure 8: Event analysis.

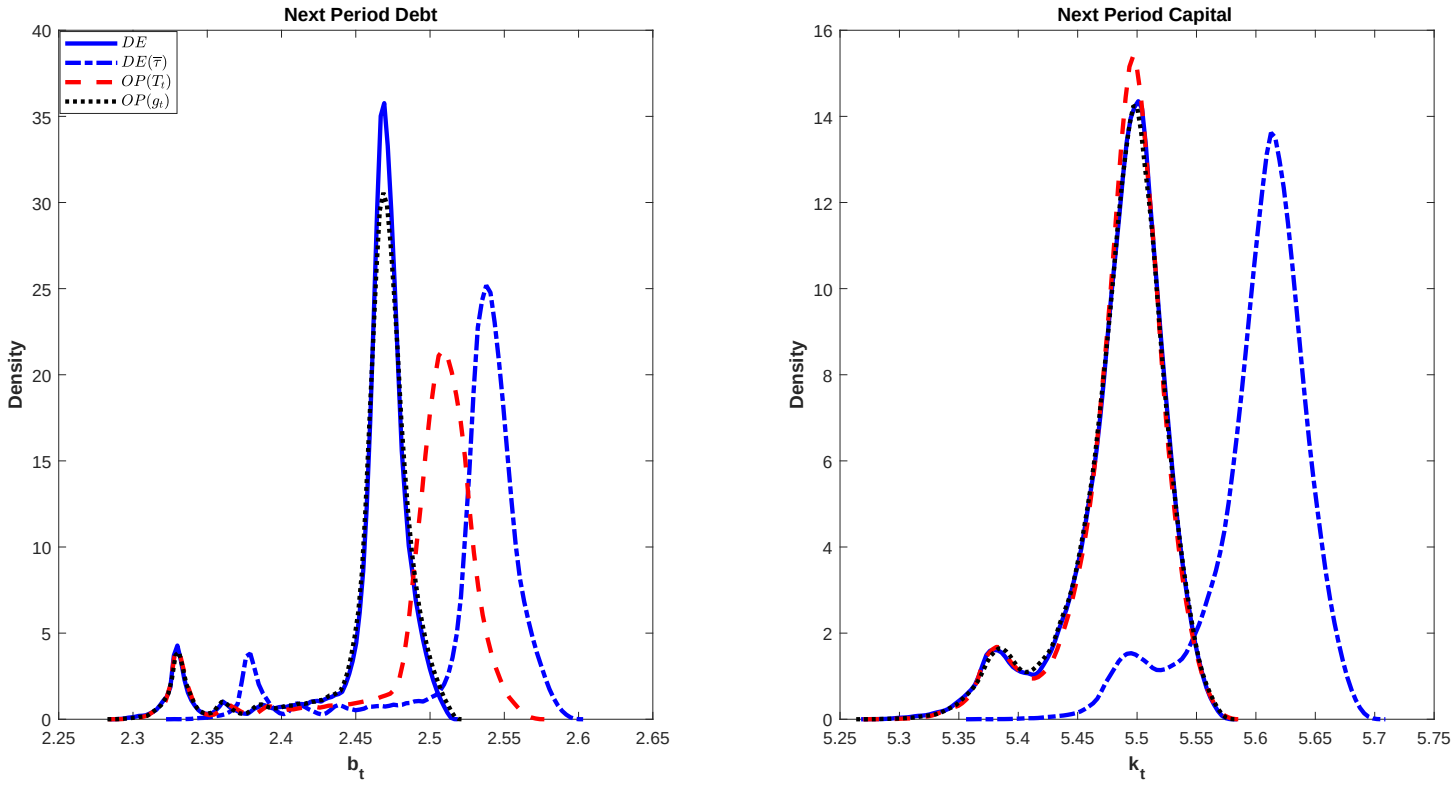

Figure 9: Limiting Distributions.

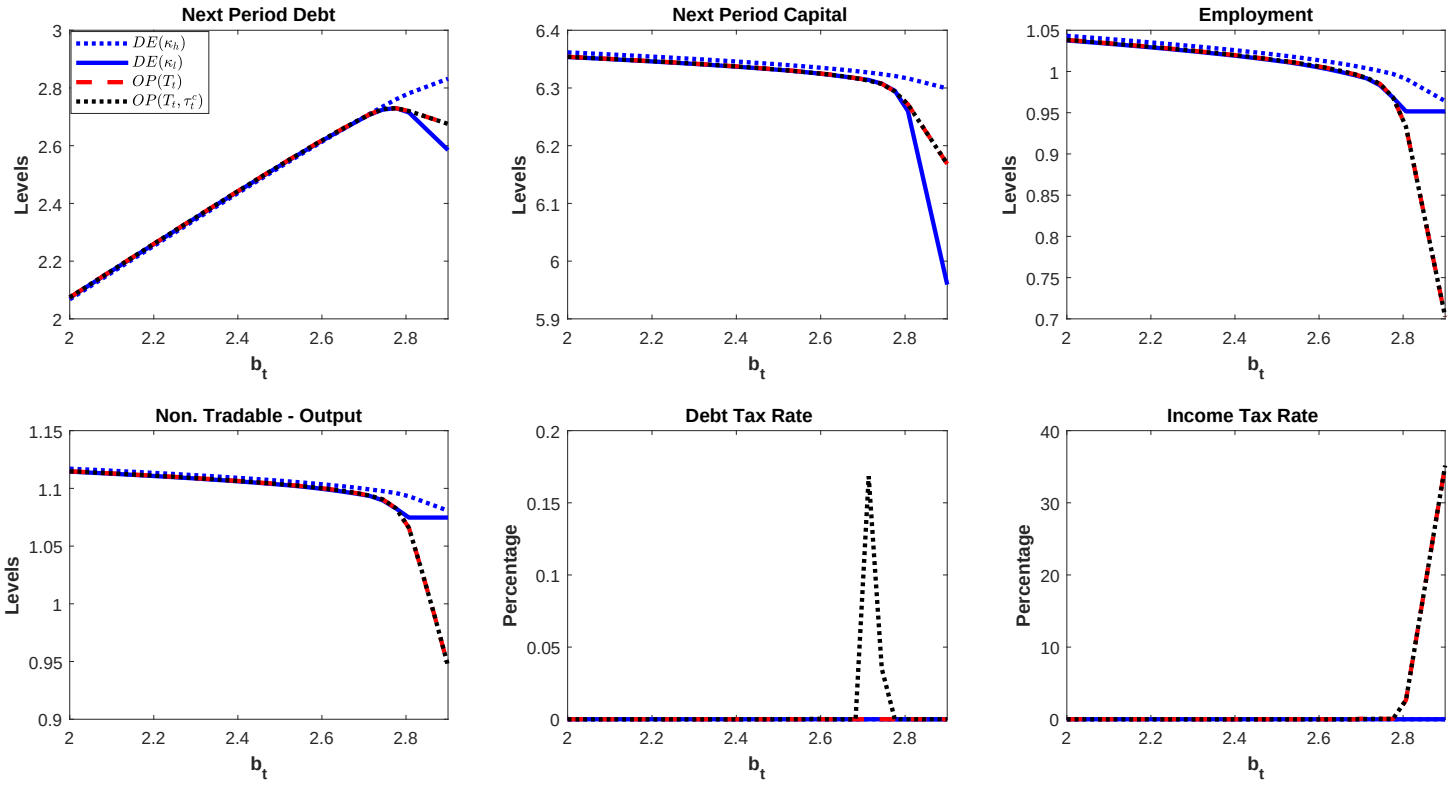

Figure 10: The dashed (solid) blue line shows the policy functions when constraints are slack κ_h (binding κ_l). The dashed red and black lines show the laws of motions with bailouts and capital control policies under the tight borrowing regime respectively.

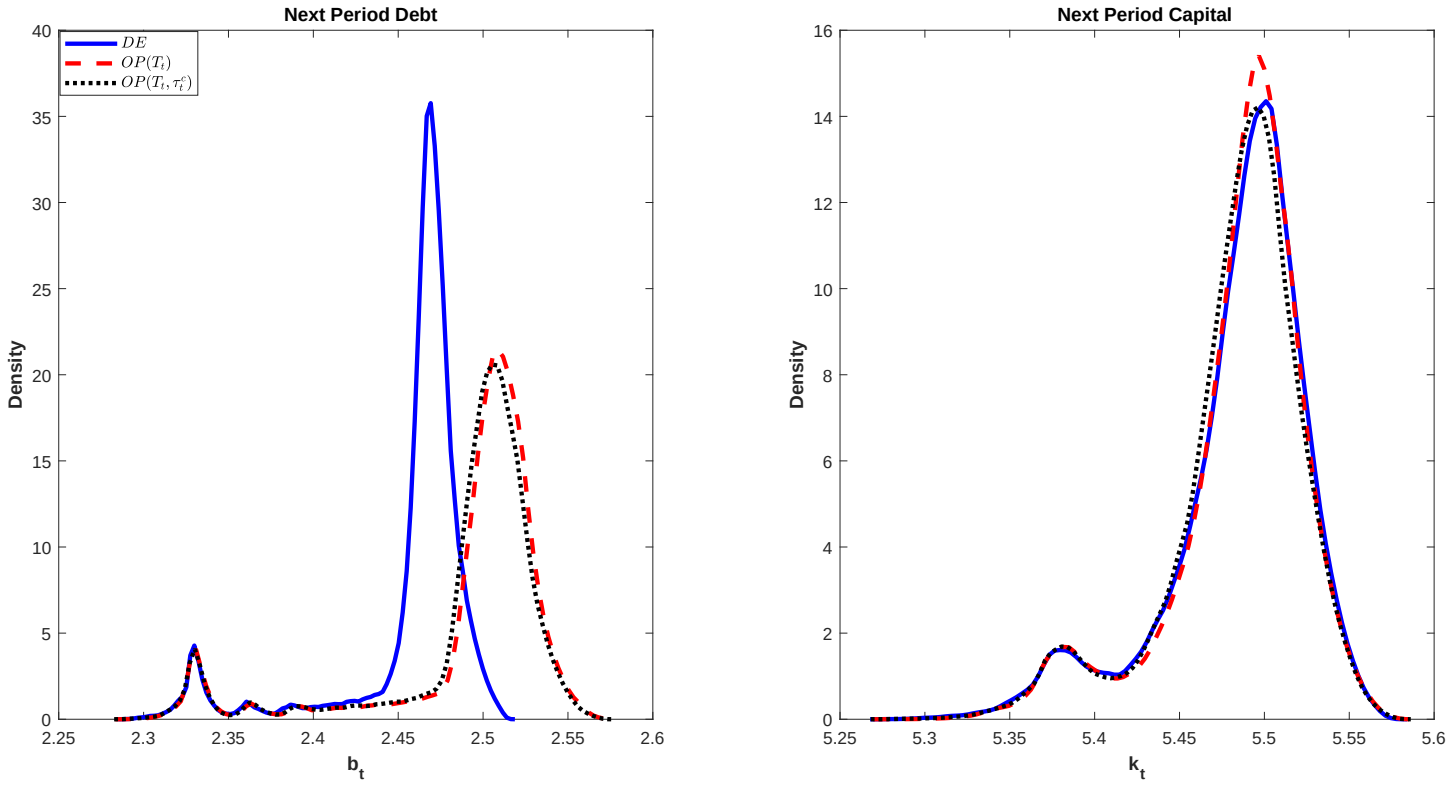

Figure 11: Limiting Distributions.

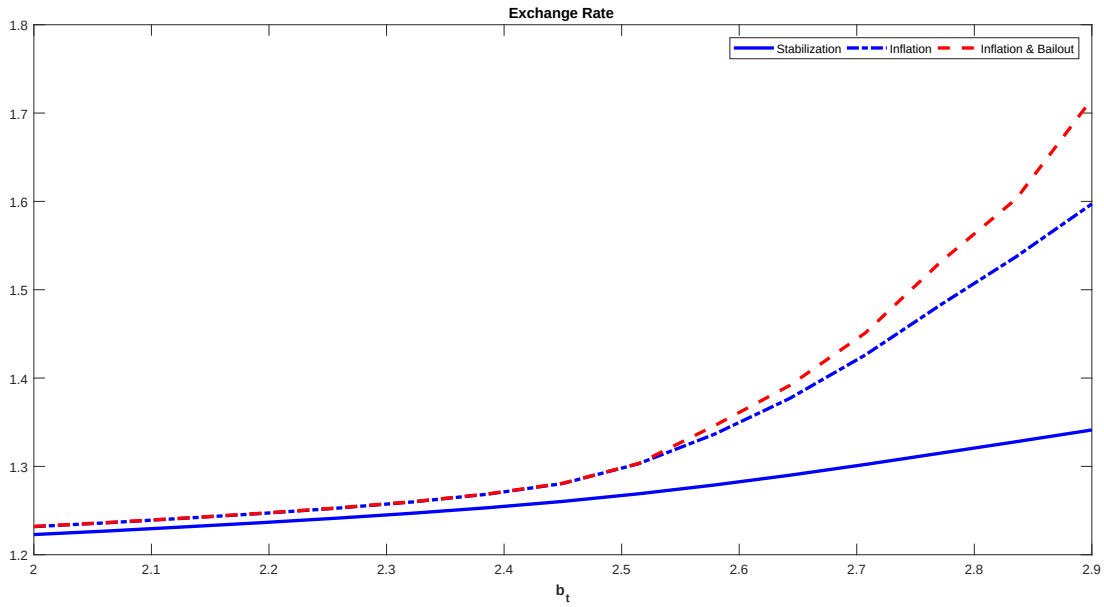

Figure 12: The figure shows the exchange rate under inflation stabilization policy (Stabilization), optimal inflation policy without bailouts (Inflation) and optimal inflation policy with optimal bailouts (Inflation & Bailout).

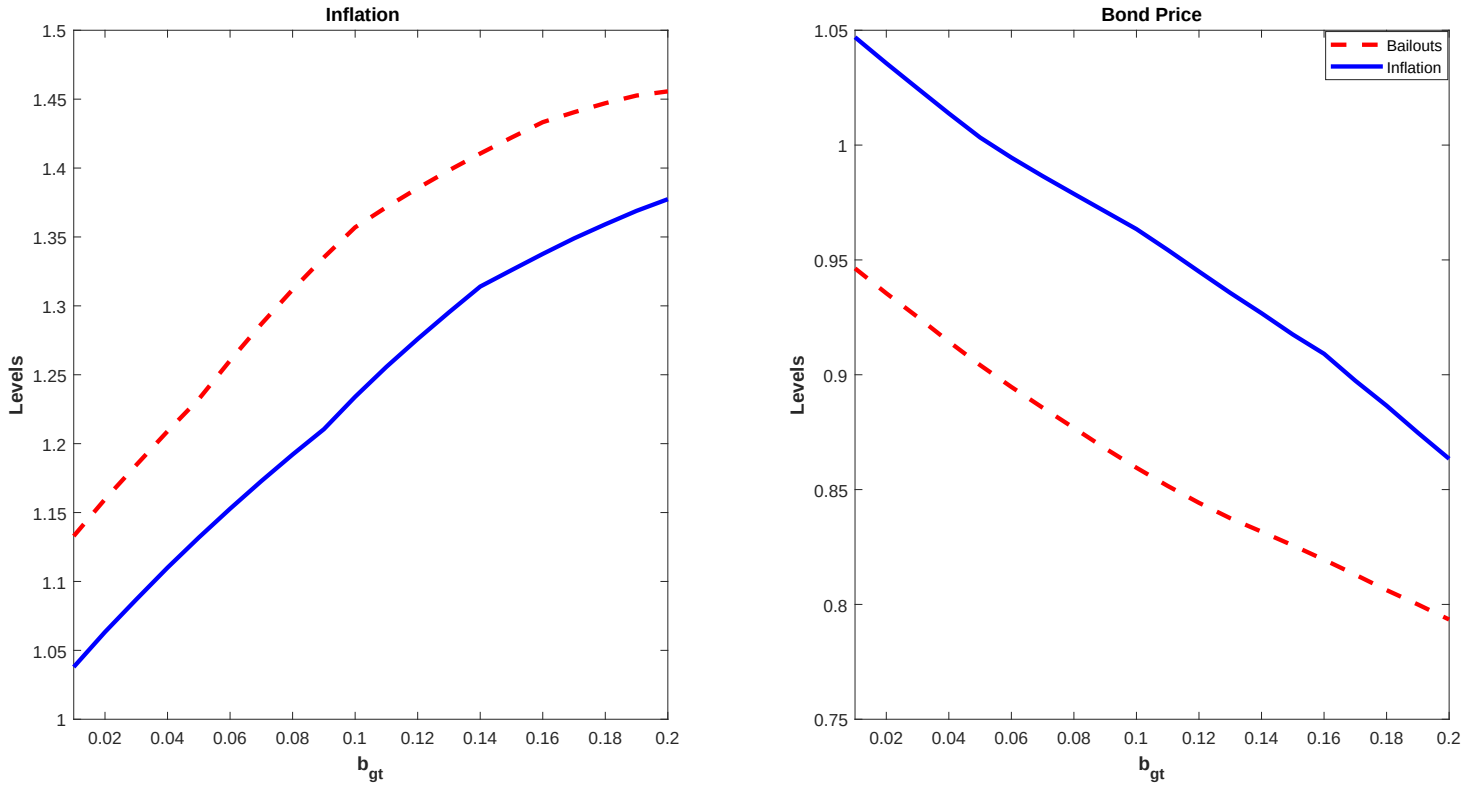

Figure 13: The figure shows inflation and the price of nominal debt under optimal inflation and bailout policies.

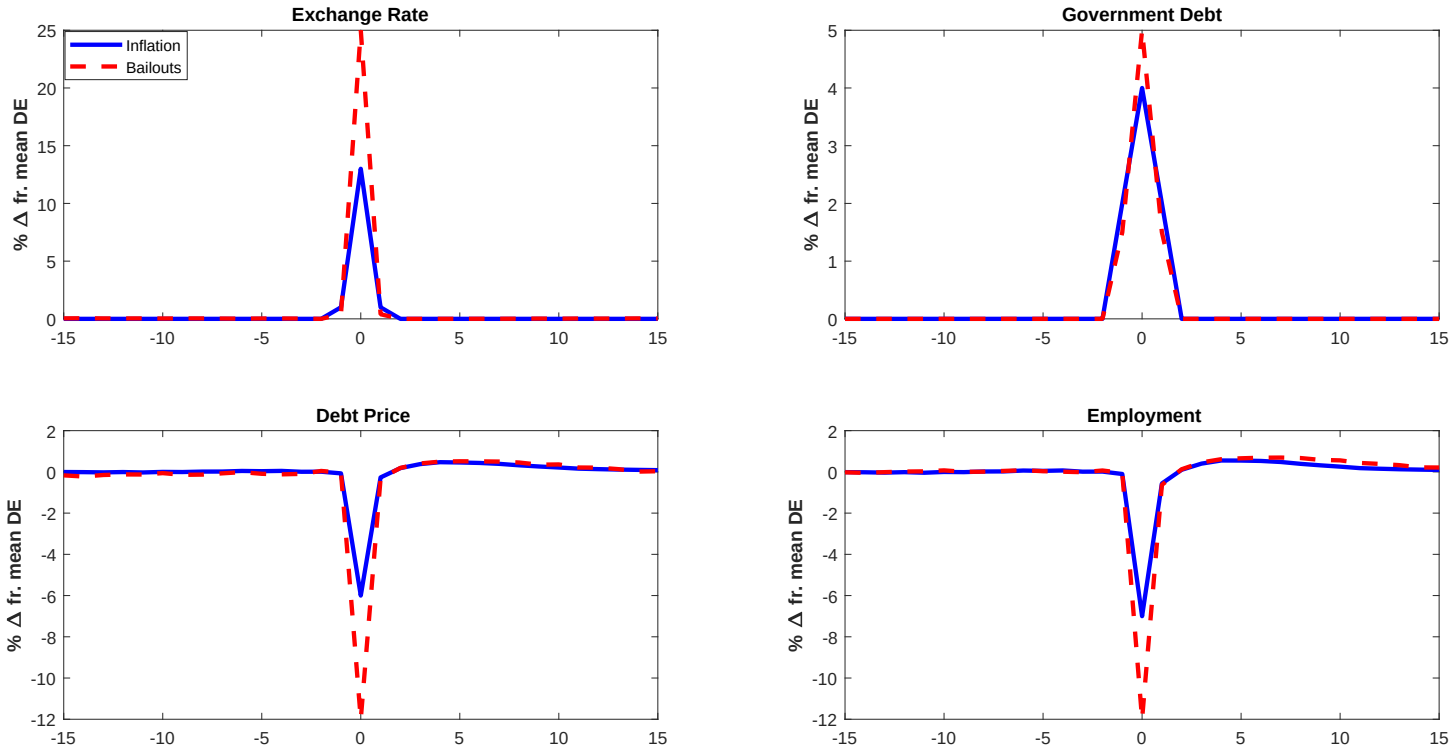

Figure 14: Event analysis.

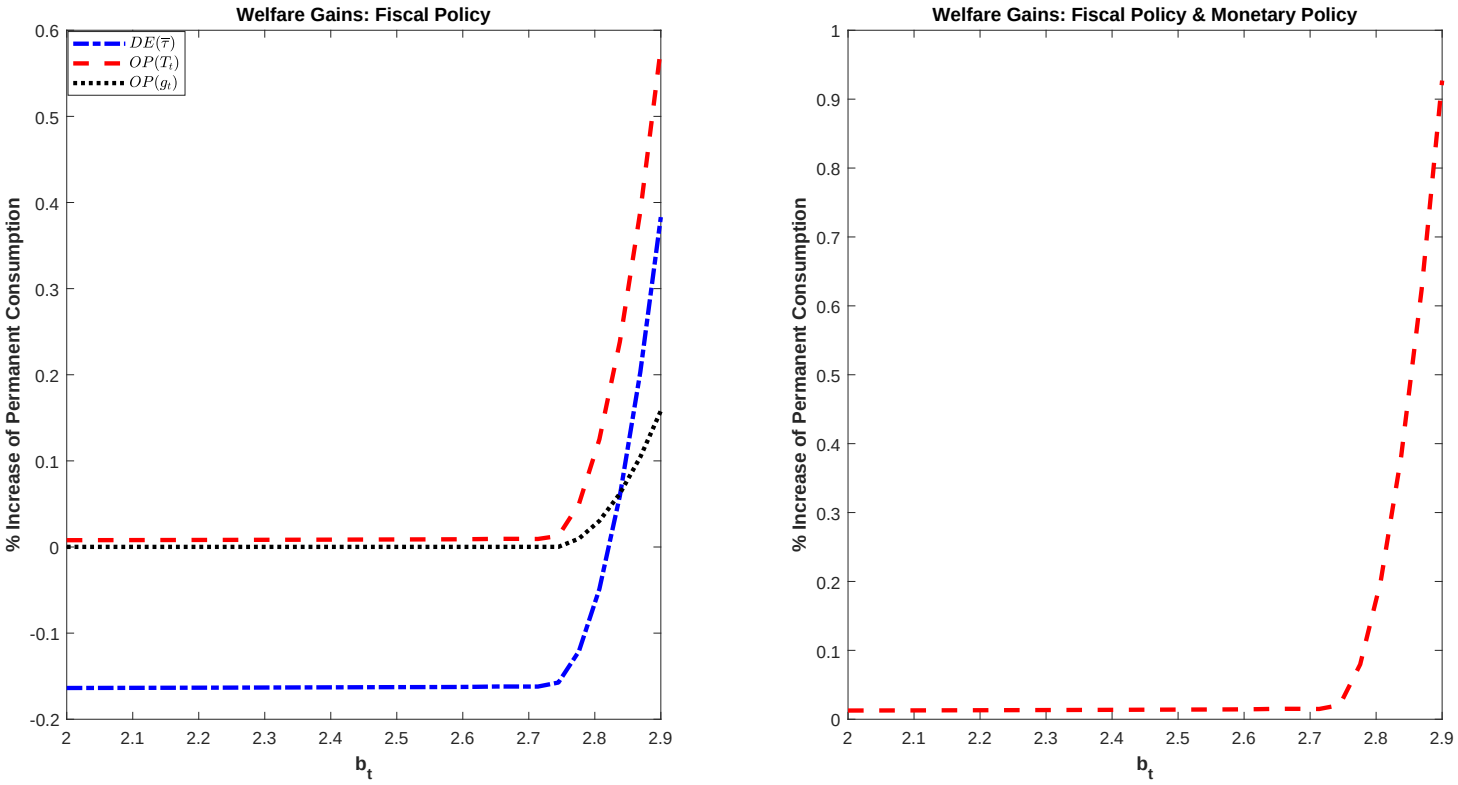

Figure 15: Welfare gains as percent of c_t.

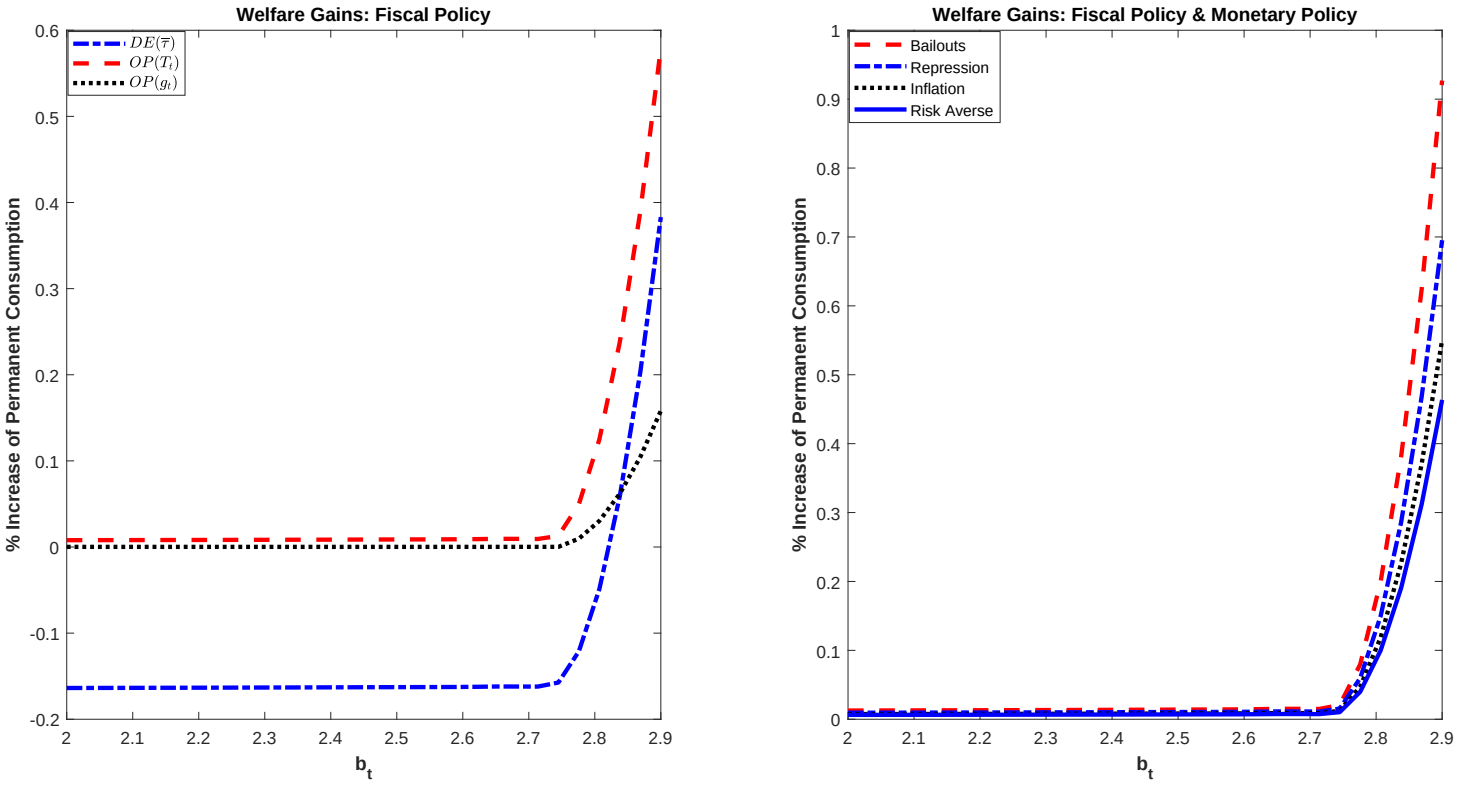

Figure 16: Welfare gains as percent of c_t.

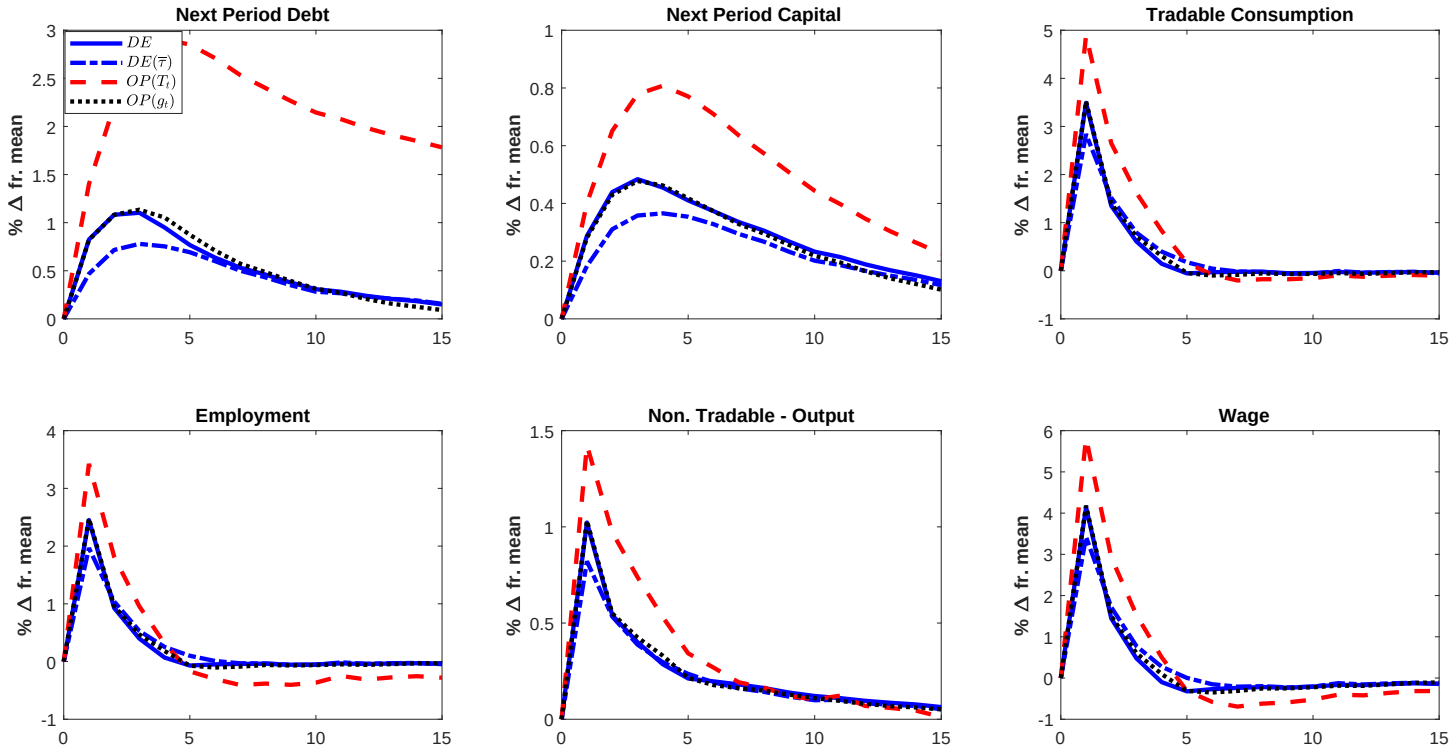

Figure 17: The non-linear impulse response functions to a positive tradable income shock. The solid (dashed) line shows the impulse response functions of the benchmark model (bailouts and price support models).

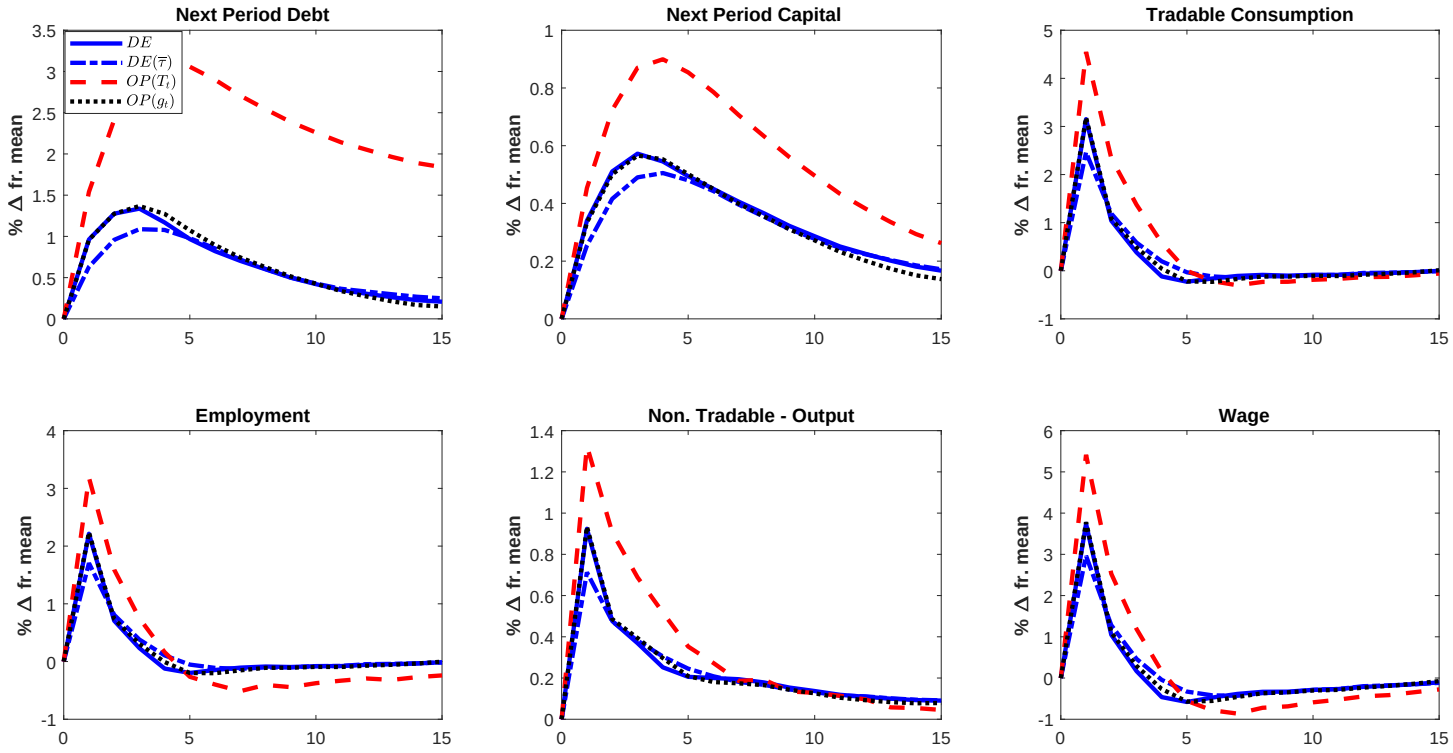

Figure 18: The non-linear impulse response functions to a negative interest rate shock. The solid (dashed) line shows the impulse response functions of the benchmark model (bailouts and price support models).

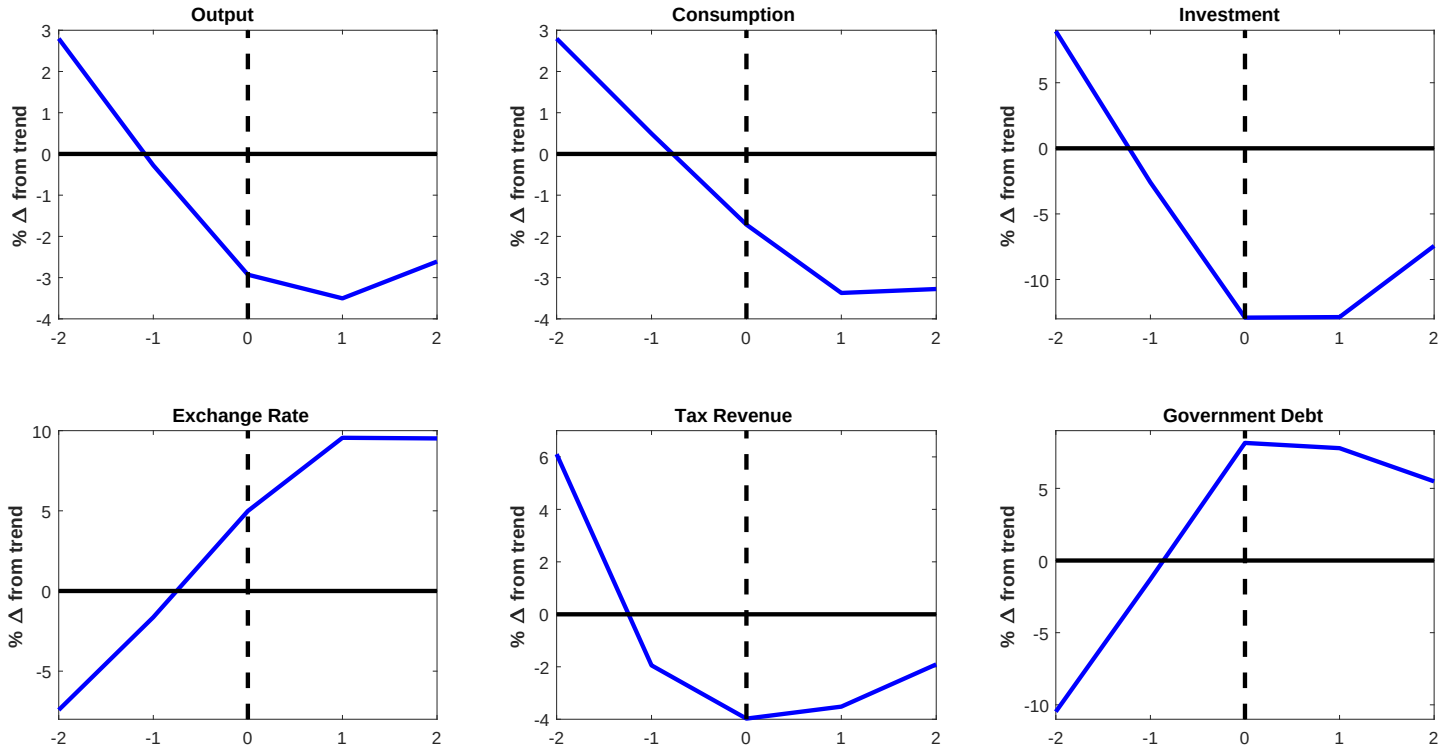

Figure 19: Crisis starts at period 0. x-axis denotes the distance from a crisis. y-axis shows the percent deviation of a variable from its trend.

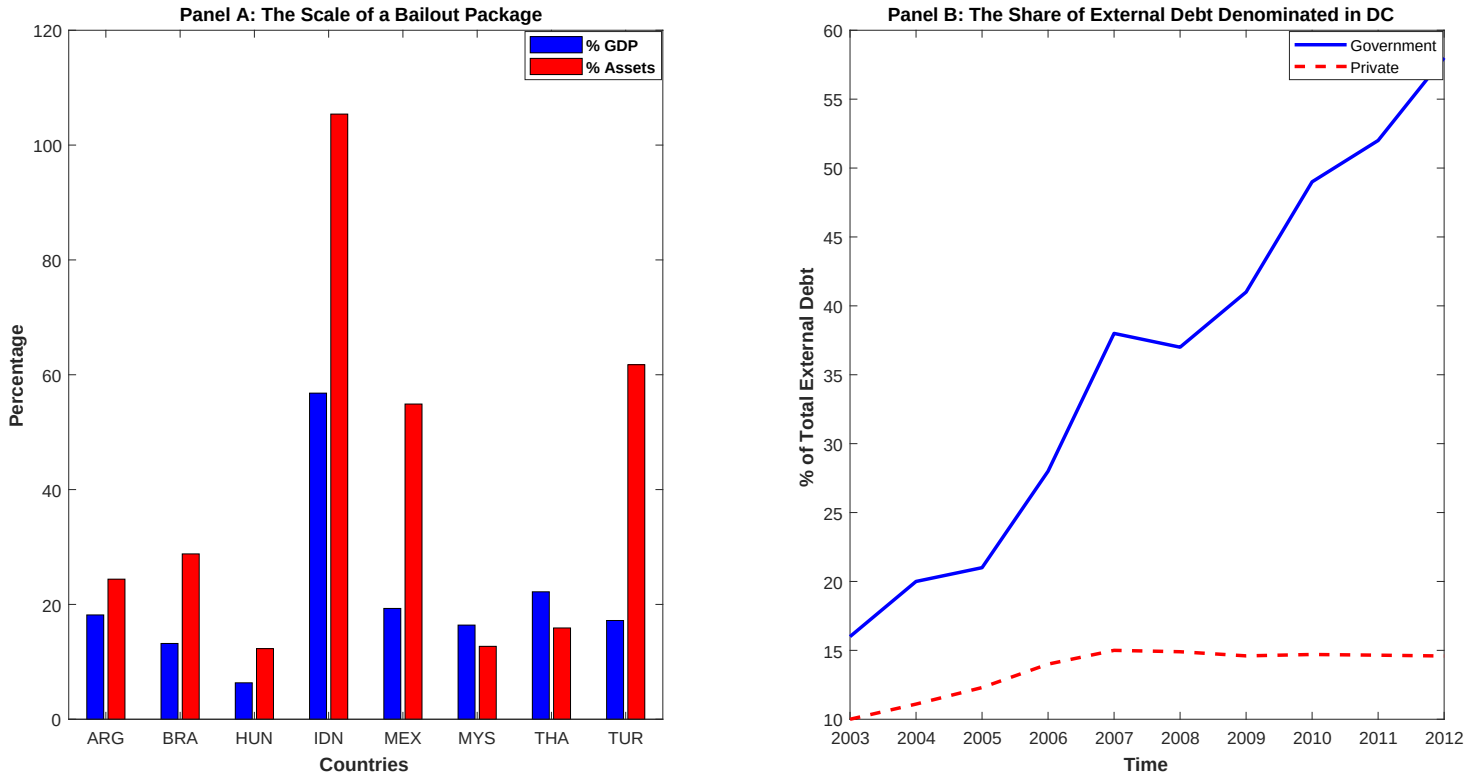

Figure 20: Panel shows the average scale of bailouts as percent of GDP and financial assets. Panel B plots the share of government and private sector debt as percent of external debt.

A.5 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: Correlations between the lag of the FC liability and var $\in$ {depreciation, inflation, tax revenue, government debt} for some selected countries and emerging market average. Depreciation (inflation) is the change in nominal exchange rate (consumer price index) from t to $t-1$.

	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 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	0.01	I/Y
α_k	Capital Share	0.33	Standard
α_v	Imports Share	0.30	Standard
α_h	Labor Share	0.31	Standard
χ	Labor Disutility	0.69	$\overline{h} = 1$
z	Output Scale	0.42	$y^N = 1$
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 3: Parameter Values

b	e	π^N	$\hat{b}_g$	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