Monetary Conservatism and Sovereign Default*

Joost Röttger†

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Abstract

The introduction of an independent central bank is often considered to be an effective way to combat high inflation rates that result from policy makers' lack of commitment. However, many economies are subject to frictions that could undermine the success of such a reform. This paper studies the consequences of delegating monetary policy to an inflation conservative central banker as in Rogoff (1985) for an economy that faces (i) incomplete financial markets, (ii) risk of default and (iii) political distortions. To do so, an Arellano-Eaton-Gersovitz-type model of sovereign default is developed in which monetary and fiscal policy is set by two different authorities that both cannot commit to future policies. Inflation conservatism results in lower and more stable inflation as well as a higher average debt burden, more frequent default events and more volatile fiscal policy. The sign of the net welfare effect related to the appointment of a conservative central banker depends on the degree of political distortions.

Keywords Monetary Conservatism, Public Debt, Lack of Commitment, Sovereign Default, Political Economy

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†University of Cologne, Center for Macroeconomic Research, Albertus-Magnus-Platz, 50923 Cologne, Germany; Email: `roettger@wiso.uni-koeln.de`.

1 Introduction

At least since the seminal work of Kydland and Prescott (1977) and Barro and Gordon (1983a), it is known that the optimal monetary policy under commitment often is time inconsistent and hence not going to be implemented by a benevolent policy maker who - quite realistically - is unable to commit to future actions. More specifically, when monetary policy is set under discretion, it tends to result in an inflation bias, i.e. an inflation rate that is persistently higher than the optimal one under commitment. This result holds for model environments where monetary policy is tempted to use surprise inflation to stimulate the economy (see e.g. Barro and Gordon, 1983a, or Clarida and Gertler, 1999) or relax the government budget by reducing the real value of outstanding nominal public debt payments (see e.g. Lucas and Stokey, 1983).[1] In doing so, the policy maker does not internalize that rational agents anticipate the use of such inflationary policies in earlier periods which (partially) offsets the potentially positive effects of inflation surprises. To avoid (or at least reduce) this inflation bias, Rogoff (1985) has suggested the delegation of monetary policy to a monetary conservative central banker who views inflation as more costly than society. Although he is not benevolent, his appointment makes monetary policy less tempted to resort to inflationary policies and might thus increase welfare relative to a scenario with a benevolent policy maker.

In practice, most developed economies have delegated monetary policy to independent central banks that emphasize low and stable inflation. These reforms have shielded monetary policy from the sequential nature of policy making in democratic societies and have usually been accompanied by lower inflation rates. Recently, many emerging economies have also introduced central bank independence in an attempt to bring down their persistently high inflation rates (see e.g. Carstens and Jácome, 2005). However, a lot of these countries are subject to frictions that might undermine the success of such reforms.

This paper studies the effectiveness and desirability of monetary conservatism in a model which accounts for three frictions that matter for many emerging economies: (i) incomplete financial markets, (ii) risk of default, and (iii) political distortions. I study a model of a small open economy where fiscal and monetary policy is chosen without commitment. In this case, the presence of nominal non-state contingent government debt introduces an incentive to reduce the real debt burden by using surprise inflation or default and relax the government budget. In the model, fiscal policy, which involves the provision of a public good, borrowing and debt repayment, is controlled by a fiscal authority that exhibits a deficit

[1] See Nicolini (1998) for a discussion about how monetary policy might also be tempted to use surprise deflation, resulting in a deflation bias under discretionary policy. However, this case does not seem to be particularly relevant in practice for most countries.

bias due to political economy frictions whereas monetary policy is set by an independent central bank. Reflecting its independence, the central bank's objective might differ from that of the fiscal authority and society. In particular, the central bank is not subject to political economy constraints and might place a higher value on price stability (see Rogoff, 1985, or Adam and Billi, 2008). The interaction between the fiscal authority and the central bank is modeled as a Markov-perfect game (see e.g. Niemann, 2011).

The frictions (i)-(iii) matter for the implications of monetary conservatism for the following reasons. When the central bank places a higher (utility) weight on inflation than the fiscal authority and society, it is less tempted to use inflation to reduce the real debt burden. However, when financial markets are incomplete and only non-state contingent bonds can be issued, this also implies that the central bank is less willing to use adjust inflation in response to fiscal shocks to make real debt payments state contingent. As a result, even if monetary conservatism can bring down inflation, it is not clear that this is indeed welfare enhancing. The central bank's willingness to use inflation might also affect the economy's vulnerability to sovereign debt crises (see e.g. Kocherlakota, 2014). The more conservative the central bank is, the more attractive the default option might become for the fiscal authority to relax the government budget, potentially increasing the likelihood of a debt crisis. Finally, political frictions might render a higher credibility for low inflation costly as well. When a fiscal authority exhibits a deficit bias, for instance - as in this paper - due to political disagreement and turnover risk (see Cuadra and Sapriza, 2008, or Aguiar and Amador, 2011), it has a long-run borrowing motive that does not reflect the preferences of society. A central bank that is less tempted to raise inflation will tend to lower inflation risk and hence nominal interest rates which could encourage the fiscal authority to borrow more and reduce household welfare even further (see also Aguiar, Amador, Farhi, and Gopinath, 2014).

The main finding of this paper is that an economy with a more conservative central bank ends up with more debt, more frequent default events and lower inflation. Monetary conservatism can thus successfully reduce the inflation bias. This success comes however at a cost. By lowering expected inflation and hence nominal interest rates, it makes debt accumulation more attractive for the fiscal authority and thereby exposes the economy more often to sovereign debt crises since the incentive to default increases with debt. By reducing the time-inconsistency problem related to inflation, monetary conservatism aggravates the time-inconsistency problem related to sovereign default. The resulting increase in sovereign risk leads to more sensitive interest rates which in turn make it more costly to smooth government spending in response to bad fiscal shocks. As a result, fiscal policy becomes more volatile when the degree of monetary conservatism is increased. A welfare comparison reveals that whether the benefits of lower and more stable inflation outweigh the welfare costs of experiencing higher average debt, more frequent debt crises and more volatile fiscal policy depends on the political frictions. While there are net welfare gains of monetary conservatism for the baseline model calibration, varying the degree of the political distortions can reverse this finding and result in net welfare costs.

Related Literature This paper is related to three strands of literature. First, it is related to recent papers that study central bank independence in the presence of nominal government debt and lack of commitment. In particular, it relates to Niemann (2011) who studies a Markov-perfect policy game between a monetary conservative central bank and a myopic fiscal authority, using the cash-in-advance model of Nicolini (1998). In his model, the fiscal authority has a lower discount factor than society and does not internalize the effect of its borrowing decision on future policy. When nominal debt is the only source of the time-inconsistency problem, he shows that monetary conservatism backfires. While it lowers average inflation when the degree of monetary conservatism is sufficiently high, it encourages the fiscal authority to borrow more in the long run, decreasing welfare. Other related papers are Niemann, Pichler, and Sorger (2013) and Martin (2015) who also investigate central bank independence in models with nominal debt and lack of commitment but abstract from monetary conservatism.[2] All of these papers do not consider sovereign default, micro-founded political distortions and uncertainty.

Second, this paper is related to the recent literature on sovereign default and incomplete markets (see e.g. Aguiar and Amador, 2014 for details). Within this growing literature, the studies that are closest to this paper are Cuadra and Sapriza (2008), Du and Schreger (2015) and Nuño and Thomas (2015).[3] The former paper introduces political polarization and turnover risk into the sovereign default model of Arellano (2008), showing that such political frictions make policy makers act in a more impatient manner. In this paper, the economy faces similar political distortions. Du and Schreger (2015) develop a quantitative sovereign default model in which a government can reduce the real debt burden by raising inflation (and thereby depreciating the domestic currency) at the cost of hurting the balance sheet of domestic firms which issue debt denominated in foreign currency and earn revenues in local currency.[4] Nuño and Thomas (2015) study a continuous-time model in which a policy maker borrows from abroad and monetary policy is either chosen under discretion or always following a zero-inflation policy that is

[2] Adam and Billi (2008) study the role of monetary conservatism in a sticky price model with endogenous fiscal policy but without public debt.

[3] Sunder-Plassmann (2014) and Röttger (2015) are related to this paper as well. While these papers also jointly study monetary policy and sovereign default, they focus on closed production economies with cash-in-advance constraints and a single benevolent policy maker.

[4] Na, Schmitt-Grohé, Uribe, and Yue (2015) also study a model where the government can default as well as devalue the local currency. However, they exclusively look at externally held foreign currency debt.

not responsive to the state of the economy. In contrast to this paper, they consider a benevolent policy maker. The authors find that the economy is better off when the government is not tempted to reduce the real debt burden via inflation. They also briefly consider the case of delegating monetary policy to a monetary conservative central bank but do not allow for political distortions and do not discuss how disagreement between the fiscal and the monetary authority might affect outcomes.

Third, this paper is related to Aguiar, Amador, Farhi, and Gopinath (2013, 2015). Aguiar, Amador, Farhi, and Gopinath (2013) study a continuous-time model of discretionary monetary and fiscal policy where default events are self-fulfilling in the spirit of Cole and Kehoe (2000). Building on this paper, Aguiar, Amador, Farhi, and Gopinath (2015) consider a model of a monetary union with a continuum of countries which independently choose fiscal policy and a common central bank that is in charge of monetary policy. They show the existence of a fiscal externality that encourages countries to overborrow. In contrast to this paper, the authors focus on benevolent policy makers and thus do not allow for political frictions and varying degrees of central bank independence. In addition, they abstract from fundamental uncertainty and only consider sunspot-driven default events.[5]

The rest of this paper is organized as follows. Section 2 describes the model. Section 3 discusses the main policy trade-offs. Section 4 presents the quantitative model analysis. Section 5 concludes.

2 Model

In the model, there is a small open economy and a continuum of risk-neutral foreign investors. The small open economy is inhabited by households and a government. The government consists of two independent authorities: a central bank and a fiscal authority. In the economy, there are two political parties that might be in charge of the fiscal authority. These parties randomly enter and leave office, i.e. only one party chooses fiscal policy in a given period.

2.1 Households

Consider a small open economy that is inhabited by a unit-mass continuum of households. Time is discrete, indexed with $t = 0, 1, 2, ...$ and goes on forever. Households have preferences over private

[5] Other recent papers that study the interaction between monetary policy and self-fulfilling sovereign debt crises are Araujo and Santos (2013), Da-Rocha, Gimenez, and Lores (2013), Corsetti and Dedola (2014) and Bachetta and van Wincoop (2015).

consumption c_t and a public good g_t, given by

$$\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t\tilde{U}\left(c_t,g_t\right)\right],\ 0<\beta<1,$$

where the period utility function is given by

$$\tilde{U}\left(c_t,g_t\right)=c_t+u\left(g_t\right),$$

with $u_g\left(\cdot\right),-u_{gg}\left(\cdot\right)>0$.[6] Households face the period budget constraint

$$y_t=c_t+\tau_t+\psi(\pi_t),$$

where y_t is an exogenous endowment that they receive in each period, τ_t are exogenous tax payments and $\psi(\pi_t)$ are resource losses of inflation as in Calvo and Guidotti (1992) that satisfy $\psi_\pi\left(\cdot\right),\psi_{\pi\pi}\left(\cdot\right)>0$.[7] The endowment y_t is in terms of a tradable good that will be the numeraire in the model. Its international price is normalized to one.

Using the period budget constraint to eliminate private household consumption and dropping policy-invariant terms, welfare of the average citizen can be written as

$$\mathcal{U}=\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^tU\left(g_t,\pi_t\right)\right],$$

with

$$U\left(g_t,\pi_t\right)=u\left(g_t\right)-\psi\left(\pi_t\right).$$

This welfare measure reflects the preferences of society and will be used to evaluate the welfare properties of public policy.[8]

2.2 Government

In the economy, a government is in charge of setting monetary and fiscal policy. This government consists of two separate entities: a fiscal authority and a monetary authority (from now on referred to as central bank). Both authorities re-optimize in each period and cannot commit to future policies.

[6]The same quasi-linear household utility function is also used in Cole and Kehoe (2000).
[7]These resource losses could, for instance, be interpreted as price adjustment costs in the spirit of Rotemberg (1982).
[8]Aguiar, Amador, Farhi, and Gopinath (2013, 2015) directly assume a utility cost of inflation.

2.2.1 Fiscal Authority

Similar to Cuadra and Sapriza (2008), the fiscal authority is controlled by either one of two political parties. These parties have symmetric objectives and randomly enter and leave office. More specifically, the incumbent party remains in office in the subsequent period with constant probability μ and is replaced by the opposite party with probability $1-\mu$.[9]

In each period. The objective of political party $i \in \mathbb{I} \equiv \{1,2\}$ is given by

$$\mathcal{F}_i = \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t U_i^{\mathcal{F}} (g_t, \pi_t) \right],$$

where

$$U_i^{\mathcal{F}} (g_t, \pi_t) = \tilde{\theta}_{it} u (g_t) - \psi (\pi_t),$$

with $\tilde{\theta}_{it} = \theta > 1$ if party i is in office and $\tilde{\theta}_{it} = 1$ if it is not.

In each period, the fiscal authority chooses the supply of the public good, trades one-period bonds with foreign investors and decides on whether to repay outstanding debt or not as in Eaton and Gersovitz (1981). As in Aguiar and Amador (2011), both political parties place a higher weight θ on the utility derived from the public good when they are in office.[10] While the political parties disagree about the value of the public good, there is no disagreement about the cost of inflation $\psi(\pi_t)$. However, $\tilde{\theta}_{it}$ leads to disagreement about the optimal inflation rate between the two parties since the incumbent party places a lower relative weight on the cost of inflation $\psi(\pi_t)$.[11]

The weight $\tilde{\theta}_{it}$ can be interpreted in several ways (see Aguiar and Amador, 2011, p. 661). For instance, it can represent disagreement between the two political parties about the implementation of public policy, leading to a higher marginal utility of public consumption for the incumbent political party since it can carry out its desired policy. Another interpretation for the assumption $\theta > 1$ could be that it is a shortcut for the incumbent's ability to divert public funds into its own pocket via pork-barrel spending (see e.g. Battaglini and Coate, 2008) or corruption.

For simplicity, I assume that the political parties have completely symmetric objectives. In addition, once in office, the probability of being in office in the next period μ is the same for both parties.[12] These

[9] See Scholl (2016) for a quantitative sovereign default model with endogenous turnover risk.

[10] Cuadra and Sapriza (2008) consider a model with two population groups where each group is favored by one of two potentially ruling parties.

[11] Aisen and Veiga (2005) document a positive relationship between political instability and average inflation. The fiscal authority's lower relative emphasis on price stability compared to society is consistent with this pattern.

[12] On average, a newly appointed incumbent thus spends $1/(1-\mu)$ subsequent periods in office.

assumptions imply that - for the recursive model formulation below - there is no need to keep track of which particular party is in office since they will choose the same policies in a symmetric equilibrium. To smooth public spending across states, the government can trade nominal and real one-period bonds with risk-neutral foreign investors. These bonds are non-state contingent and defaultable, i.e. the fiscal authority can refuse to repay bondholders. Following the recent sovereign default literature, a default is costly because of direct resource costs and a temporary loss of access to international financial markets (see e.g. Aguiar and Gopinath, 2006, or Arellano, 2008).

The presence of political disagreement and turnover risk leads the fiscal authority to exhibit a present bias that makes it behave similarly to a decision maker who discounts in a quasi-geometric fashion (see Laibson (1997), Krusell, Kuruscu, and Smith, 2002).[13] As a result, it is more biased towards the present compared to a policy maker who does not face the risk of leaving office. In the context of the model, the present bias implies that the fiscal authority has an incentive to front-load public spending by either borrowing more or defaulting on debt payments. In any period, the costs associated with these policies are (partly) borne in the future, either through increases in the primary surplus or temporary financial autarky. When less patient, these costs are discounted more by the fiscal authority, making borrowing and default more attractive policy options. It is important to note that the strength of the present bias varies with the state of the economy. The present bias of the fiscal authority in this paper thus is different from that of a policy maker who simply has a low discount factor β relative to the lenders (see Niemann, 2011, and Aguiar, Amador, Farhi, and Gopinath (2014)).

If the fiscal authority repays its debt, the period government budget constraint is

$$P_t\tau_t + q_{Nt}B_{Nt+1} + P_t q_{Rt} b_{Rt+1} \geq P_t g_t + B_{Nt} + P_t b_{Rt},$$

where P_t is the price level, q_{Nt} the price of nominal bonds B_{Nt+1} and q_{Rt} the price of real bonds b_{Rt+1}. Tax revenues τ_t are random and follow a first-order Markov process with continuous support $\mathbb{T} \subseteq \mathbb{R}_+$ and transition function $f(\tau_{t+1}|\tau_t)$.[14]

I consider exogenous tax revenues for three reasons.[15] First, for many countries it is difficult, if not

[13]Persson and Svensson (1989) and Alesina and Tabellini (1990) were the first to recognize that political polarization and turnover risk lead to a present bias. Aguiar and Amador (2011) and Chatterjee and Eyigungor (2016) show in detail how quasi-geometric discounting can result in such a political economy model (without intra-temporal trade-offs) when $\mu = 0.5$. See also Cao and Werning (2016) for a related discussion in a continuous-time setting.

[14]I will occasionally refer to shocks to tax revenues as fiscal shocks.

[15]In the context of a real economy without default but with private government information, Halac and Yared (2014) also look at a fiscal policy maker who exhibits a present bias and finances the supply of a public good with exogenous tax revenues and borrowing.

virtually impossible, to quickly change the tax code in the short run. By contrast, sudden adjustments of public spending tend to be easier to carry out in practice. Second, since the sovereign default literature mostly considers endowment economies (see e.g. Aguiar and Gopinath, 2006, or Arellano, 2008), a setting that models public resources also as an endowment makes it easier to relate the model to this literature. Third, the numerical solution of the model is quite difficult as it involves solving the decision problems of two distinct authorities. Abstracting from the tax rate as a decision variable for the fiscal authority substantially reduces the computational burden.

In real terms, the budget constraint is

$$\tau_t + q_{Nt} b_{Nt+1} + q_{Rt} b_{Rt+1} \geq g_t + \pi_t^{-1} b_{Nt} + b_{Rt},$$

with (gross) inflation $\pi_t = P_t / P_{t-1}$ and normalized nominal debt $b_{Nt} = B_{Nt} / P_{t-1}$. The initial price level $P_{-1} \in (0, \infty)$ is taken as given. For tractability reasons, I assume that nominal debt issuance b_{Nt+1} always accounts for a fixed share $\lambda \in [0,1]$ of total debt $b_{t+1} = b_{Nt+1} + b_{Rt+1}$.[16] In the repayment case, the government budget constraint then becomes

$$\tau_t + (\lambda q_{Nt} + (1-\lambda) q_{Rt}) b_{t+1} \geq g_t + \left(\lambda \pi_t^{-1} + 1 - \lambda\right) b_t,$$

while in the default case, it is

$$\tau_t - \phi(\tau_t) \geq g_t,$$

where $\phi(\tau_t) \geq 0$ are (public) resource costs of default. In the sovereign default literature, such resource costs are standard but modeled in terms of aggregate output and not in terms of public funds (see e.g. Arellano, 2008). One interpretation for public resource costs is that they result from the abandonment of public projects which leads to net losses for the government. Another interpretation is that in the default case, the country experiences a decline in tax morale which makes it more difficult for the government to collect tax payments. As a result, it has to spend additional resources on tax enforcement to raise a given amount of revenues τ_t.

[16] Chatterjee and Eyigungor (2012) make a similar assumption in a model with long-term debt. They keep the debt maturity structure fixed and let the sovereign choose the level of debt. In this paper, it is the currency composition of debt that is kept constant. I allow for a nominal debt share that is not equal to one to compare the effects of changing the currency composition of debt with the effects of changing the monetary policy stance.

2.2.2 Central Bank

Monetary policy is controlled by the central bank. I assume that the central bank can directly choose the inflation rate by setting its policy instruments in an appropriate way. Reflecting its independence, the central bank's objective may differ from that of the fiscal authority:

$$\mathcal{M} = \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t U^{\mathcal{M}} \left(g_t, \pi_t \right) \right],$$

where

$$U^{\mathcal{M}} \left(g_t, \pi_t \right) = u \left(g_t \right) - \alpha \psi \left(\pi_t \right),$$

with $\alpha \geq 0$.

Following the literature (see Rogoff, 1985, Adam and Billi, 2008, and Niemann, 2011), monetary policy is delegated to a monetary conservative central banker who has the same preferences as the average citizen, except that he has an inherent distaste for inflation: $U^{\mathcal{M}} \left(g_t, \pi_t \right) = U \left(g_t, \pi_t \right) - (\alpha - 1) \psi \left(\pi_t \right)$. The parameter α is the central banker's degree of monetary conservatism.[17] For $\alpha > 1$ ($\alpha < 1$), the central banker values price stability more (less) than society. Since the economy (partly) borrows in its own currency, the central bank can reduce the real debt burden and relax the government budget by raising inflation. The temptation to do so strongly depends on α. In contrast to the fiscal policy maker, the central banker is not subject to political risk and remains in power forever. Importantly, the central banker also does not derive additional utility from the public good like the incumbent political party. In the economy, the degree of central bank independence thus is characterized by the central bank's monetary conservatism and its independence from political economy considerations. For $\alpha = \alpha_\theta \equiv 1/\theta$, the central bank puts the same relative weights on $u(g)$ and $\psi(\pi)$ as the fiscal authority. This case will be a useful benchmark since it implies that the main source of (intertemporal) disagreement between the fiscal and the monetary authority is the fiscal authority's present bias.

2.2.3 Policy Interaction

The interaction between the political parties, which determines the actions of the fiscal authority, and the interaction between the fiscal authority and the central bank is modeled as a Markov-perfect game (see e.g. Niemann, Pichler, and Sorger (2013)). As is common in the literature, I restrict attention to

[17] Aguiar, Amador, Farhi, and Gopinath (2013) refer to this parameter as "inflation credibility" in a model without delegated monetary policy.

stationary equilibria. In a stationary Markov-perfect equilibrium, the policy functions that characterize the optimal decisions of the two authorities only depend on the minimal payoff-relevant state, which includes the beginning-of-period debt position b_t.[18] As in Cuadra and Sapriza (2008), I only study symmetric equilibria in which the two political parties choose the same policies when in power, given the aggregate state. This way, fiscal policy does not depend on which party is in office. Because the two authorities optimize under discretion, they do not internalize the effect of their actions on previous periods and have no incentive to honor promises made by policy makers in the past. As a result, they cannot credibly commit to carry out specific actions in the future and take the policies set in the subsequent period as given. However, since these policies will depend on the future aggregate state, the authorities can influence the way public policy is conducted in the future via the debt position b_{t+1}.

Conditional on entering a period with debt b_t, the within-period timing is as follows. First, the revenue shock τ_t is realized and the office-holder is determined. Then, the fiscal authority chooses whether to repay its debt. After this, the central bank sets the inflation rate, followed by the fiscal authority's spending and borrowing decisions. Conditional on the default decision, the two authorities thus play a Stackelberg game with the central bank acting as the Stackelberg leader. This particular timing is chosen for two reasons. First, it implies that the central bank is not powerless and can influence the decisions of the fiscal authority via the inflation rate. If the fiscal authority were the Stackelberg leader and made all its decisions before the central bank acts, it could effectively also control the inflation rate since the central bank would have no other choice than to set the inflation rate that satisfies the budget constraint.[19] Second, the value and policy functions are not generally differentiable due to the discrete default option, which implies that the intertemporal decisions might not be characterized via Euler equations as in Niemann, Pichler, and Sorger (2013) or Martin (2015). The Stackelberg leadership timing allows to solve the model numerically by sequentially solving the decision problems of the two authorities in any period, given the respective aggregate state at the beginning of the period (see Appendix A.2 for details).

[18] Since the optimal strategies are only conditioned on the current payoff-relevant (fundamental) state of the economy, the Markov-perfect equilibrium concept rules out reputational considerations as discussed by Barro and Gordon (1983b) that rely on trigger strategies which require strategies to exhibit complex history dependence.

[19] Alternatively, one could follow Niemann, Pichler, and Sorger (2013) and assume that the fiscal authority chooses public spending but not borrowing. The end-of-period debt position then is determined residually to satisfy the budget constraint, given the spending and inflation decisions of the fiscal authority and the central bank.

2.3 International Investors

The small open economy can trade non-state contingent nominal and real bonds with a continuum of homogeneous risk-neutral foreign investors who can borrow and save on international financial markets at the real risk-free rate r_f. Although the small open economy may refuse to repay its debt, investors always honor their obligations. Risk neutrality and expected profit maximization imply the bond pricing conditions

$$q_N\left(b', \tau\right) = \frac{1}{1+r_f}\mathbb{E}_{\tau'|\tau}\left[\frac{1-\mathcal{D}(b',\tau')}{\Pi^r\left(b',\tau'\right)}\right], \tag{1}$$

$$q_R\left(b', \tau\right) = \frac{1}{1+r_f}\mathbb{E}_{\tau'|\tau}\left[1-\mathcal{D}(b',\tau')\right]. \tag{2}$$

The bond price schedules $q_N\left(b', \tau\right)$ and $q_R\left(b', \tau\right)$ reflect rational expectations of future default and inflation. Given the focus on Markov-perfect public policy, next period's default and inflation policies $\mathcal{D}(\cdot)$ and $\Pi^r(\cdot)$ depend on end-of-period debt b' as well as future tax revenues τ'. Following the sovereign default literature (see e.g. Arellano, 2008), I assume that the investors act after all public policies have been determined. As a result, the central bank and the fiscal authority anticipate how their decisions affect bond prices.

2.4 Public Policy Problems

Conditional on having access to financial markets, the beginning-of-period value of the central bank is denoted as $\mathcal{M}(s)$, that of an incumbent as $\mathcal{F}(s)$ and that of a party not in office as $\mathcal{F}^*(s)$, where $s \equiv (b, \tau)$.[20]

The default decision of the fiscal authority solves

$$\mathcal{F}(b,\tau) = \max_{d\in\{0,1\}}\left\{(1-d)\,\mathcal{F}^r(b,\tau) + d\mathcal{F}^d(\tau)\right\}, \tag{3}$$

where $\mathcal{F}^r(b,\tau)$ is the value of repayment and $\mathcal{F}^d(\tau)$ the value of default.

The beginning-of-period values of the central bank and the political party currently not in office

[20] In addition to $s = (b, \tau)$, whether the economy is in financial autarky or not also counts as a state variable in the model. The model formulation below accounts for this by formulating the public policy problem conditional on the economy's default/autarky status.

satisfy

$$\mathcal{M}(b,\tau) = (1-\mathcal{D}(b,\tau))\,\mathcal{M}^r(b,\tau) + \mathcal{D}(b,\tau)\mathcal{M}^d(\tau), \tag{4}$$

$$\mathcal{F}^*(b,\tau) = (1-\mathcal{D}(b,\tau))\,\mathcal{F}^{*r}(b,\tau) + \mathcal{D}(b,\tau)\mathcal{F}^{*d}(\tau), \tag{5}$$

where $\mathcal{D}(b,\tau)$ characterizes the optimal default decision of the fiscal authority.

After the default decision has been made, the central bank acts, solving

$$\mathcal{M}^r(b,\tau) = \max_{\pi \geq \pi_{min}} \left\{ \hat{\mathcal{M}}^r(\pi,b,\tau) \right\}, \tag{6}$$

if the fiscal authority repays and

$$\mathcal{M}^d(\tau) = \max_{\pi \geq \pi_{min}} \left\{ \hat{\mathcal{M}}^d(\pi,\tau) \right\}, \tag{7}$$

if it defaults. The lower bound on the inflation rate $\pi_{min} = 1/(1+r_f)$ ensures non-negative nominal interest rates ($q_N \leq 1$). The value functions $\hat{\mathcal{M}}^r(\pi,b,\tau)$ and $\hat{\mathcal{M}}^d(\pi,\tau)$ are the intra-period continuation values for the central bank. They are determined below and depend on how the fiscal authority sets its policies, given the inflation rate π.

For the political parties, the repayment and default values satisfy

$$\mathcal{F}^r(b,\tau) = \hat{\mathcal{F}}^r(\Pi^r(b,\tau),b,\tau), \tag{8}$$

$$\mathcal{F}^d(\tau) = \hat{\mathcal{F}}^d(\Pi^d(\tau),\tau), \tag{9}$$

$$\mathcal{F}^{*r}(b,\tau) = \hat{\mathcal{F}}^{*r}(\Pi^r(b,\tau),b,\tau), \tag{10}$$

$$\mathcal{F}^{*d}(\tau) = \hat{\mathcal{F}}^{*d}(\Pi^d(\tau),\tau), \tag{11}$$

where $\Pi^r(b,\tau)$ and $\Pi^d(\tau)$ denote the policy functions for inflation that solve the central bank's decision problem, $\hat{\mathcal{F}}^r(\pi,b,\tau)$ and $\hat{\mathcal{F}}^d(\pi,\tau)$ the intra-period continuation values for the incumbent party, and $\hat{\mathcal{F}}^{*r}(\pi,b,\tau)$ and $\hat{\mathcal{F}}^{*d}(\pi,\tau)$ the intra-period continuation values for the party not in office. When choosing whether to default or repay, the fiscal authority thus internalizes how its default decision affects the inflation rate.

After the central bank has set the inflation rate, the fiscal authority makes its spending and borrowing decisions. Its decision problem is given by

$$\hat{\mathcal{F}}^r(\pi,b,\tau) = \max_{g,b'} \left\{ \begin{array}{c} \theta u(g) - \psi(\pi) \\ +\beta \mathbb{E}_{\tau'|\tau} \left[\begin{array}{c} \mu \mathcal{F}(b',\tau') \\ +(1-\mu)\mathcal{F}^*(b',\tau') \end{array} \right] \end{array} \right\} \tag{12}$$

$$\text{subject to } 0 \leq \tau - g - \left(\lambda\pi^{-1} + 1 - \lambda\right) b + \left[\begin{array}{c} \lambda q_N(b',\tau) \\ +(1-\lambda) q_R(b',\tau) \end{array} \right] b',$$

in the repayment case and by

$$\hat{\mathcal{F}}^d(\pi,\tau) = \max_{g} \left\{ \begin{array}{c} \theta u(g) - \psi(\pi) \\ +\delta\beta \mathbb{E}_{\tau'|\tau} \left[\begin{array}{c} \mu \mathcal{F}(0,\tau') \\ +(1-\mu)\mathcal{F}^*(0,\tau') \end{array} \right] \\ +(1-\delta)\beta \mathbb{E}_{\tau'|\tau} \left[\begin{array}{c} \mu \mathcal{F}^d(\tau') \\ +(1-\mu)\mathcal{F}^{*d}(\tau') \end{array} \right] \end{array} \right\} \tag{13}$$

$$\text{subject to } 0 \leq \tau - g - \phi(\tau),$$

in the default case.

If the fiscal authority reneges on debt payments, it is excluded from international financial markets for the current period. Conditional on being in autarky, the economy regains access to international financial markets with probability δ in the following period. The average duration of financial autarky hence is $1/\delta$ periods. Regardless of whether the party currently in charge of fiscal policy defaults or repays, it remains in office in the subsequent period with probability μ and is replaced by the opposite party with the counter-probability $1-\mu$.

For the central bank, the intra-period continuation values $\hat{\mathcal{M}}^r(\pi,b,\tau)$ and $\hat{\mathcal{M}}^d(\pi,\tau)$ satisfy

$$\hat{\mathcal{M}}^r(\pi,b,\tau) = \left\{ \begin{array}{c} u(\hat{\mathcal{G}}^r(\pi,b,\tau)) - \alpha\psi(\pi) \\ +\beta \mathbb{E}_{\tau'|\tau} \left[\mathcal{M}(\hat{\mathcal{B}}^r(\pi,b,\tau),\tau') \right] \end{array} \right\}, \tag{14}$$

and

$$\hat{\mathcal{M}}^d(\pi,\tau) = \left\{ \begin{array}{c} u(\hat{\mathcal{G}}^d(\pi,\tau)) - \alpha\psi(\pi) \\ +\beta \mathbb{E}_{\tau'|\tau} \left[\delta\mathcal{M}(0,\tau') + (1-\delta)\mathcal{M}^d(\tau') \right] \end{array} \right\}, \tag{15}$$

and for the party not in office, the continuation values $\hat{\mathcal{F}}^{*r}(\pi, b, \tau)$ and $\hat{\mathcal{F}}^{*d}(\pi, \tau)$ satsify

$$\hat{\mathcal{F}}^{*r}(\pi,b,\tau) = \left\{ \begin{array}{c} u(\hat{\mathcal{G}}^r(\pi,b,\tau)) - \psi(\pi) \\ +\beta \mathbb{E}_{\tau'|\tau} \left[\begin{array}{c} \mu \mathcal{F}^*(\hat{\mathcal{B}}^r(\pi,b,\tau),\tau') \\ +(1-\mu)\mathcal{F}(\hat{\mathcal{B}}^r(\pi,b,\tau),\tau') \end{array} \right] \end{array} \right\}, \tag{16}$$

and

$$\hat{\mathcal{F}}^{*d}(\pi,\tau) = \left\{ \begin{array}{c} u(\hat{\mathcal{G}}^d(\pi,\tau)) - \psi(\pi) \\ +\delta\beta \mathbb{E}_{\tau'|\tau} \left[\begin{array}{c} \mu \mathcal{F}^*(0,\tau') \\ (1-\mu)\mathcal{F}(0,\tau') \end{array} \right] \\ +(1-\delta)\beta \mathbb{E}_{\tau'|\tau} \left[\begin{array}{c} \mu \mathcal{F}^{*d}(\tau') \\ (1-\mu)\mathcal{F}^d(\tau') \end{array} \right] \end{array} \right\}, \tag{17}$$

where $\hat{\mathcal{B}}^r(\pi,b,\tau)$, $\hat{\mathcal{G}}^r(\pi,b,\tau)$ and $\hat{\mathcal{G}}^d(\pi,\tau)$ denote the policy functions for borrowing and government spending that solve the fiscal authority's decision problems (12) and (13). These functions characterize the fiscal authority's optimal response to the inflation rate π set by the central bank. The probabilities μ and $1-\mu$ do not enter the continuation values of the central bank $\hat{\mathcal{M}}^r$ and $\hat{\mathcal{M}}^d$ since future fiscal policy does not depend on which of the political parties will be in office. The objective of the central bank does not vary with the office-holder of the fiscal authority either.

Equations (14) and (15) illustrate that inflation affects the objective of the central bank in two ways. First, there is a direct effect of π on the cost of inflation $\psi(\pi)$. Second, there is an indirect effect that operates through the optimal response functions of the fiscal authority. When solving the decision problems (6) and (7), the central bank internalizes both of these effects.

The policy functions for inflation $\Pi^r(b,\tau)$ and $\Pi^d(\tau)$ then determine

$$\mathcal{B}^r(b,\tau) = \hat{\mathcal{B}}^r(\Pi^r(b,\tau),b,\tau), \tag{18}$$

$$\mathcal{G}^r(b,\tau) = \hat{\mathcal{G}}^r(\Pi^r(b,\tau),b,\tau), \tag{19}$$

$$\mathcal{G}^d(\tau) = \hat{\mathcal{G}}^d(\Pi^d(\tau),\tau), \tag{20}$$

such that in the repayment case, the equilibrium policies will only depend on (b,τ) and in the default/autarky case on τ, since the inflation choices are conditioned on these states as well.

Conditional on having access to financial markets, the equilibrium policies are ultimately pinned down by the fiscal authority's default decision, such that

$$\Pi(b,\tau) = (1-\mathcal{D}(b,\tau))\,\Pi^r(b,\tau)+\mathcal{D}(b,\tau)\Pi^d(\tau), \tag{21}$$

$$\mathcal{B}(b,\tau) = (1-\mathcal{D}(b,\tau))\,\mathcal{B}^r(b,\tau), \tag{22}$$

$$\mathcal{G}(b,\tau) = (1-\mathcal{D}(b,\tau))\,\mathcal{G}^r(b,\tau)+\mathcal{D}(b,\tau)\mathcal{G}^d(\tau). \tag{23}$$

The Markov-perfect equilibrium for the model is then defined as follows:

Definition 1 *A stationary Markov-perfect equilibrium is given by bond pricing functions q_N and q_R that satisfy the zero-expected profit conditions (1)-(2), value functions $\{\mathcal{F},\mathcal{F}^r,\mathcal{F}^d,\hat{\mathcal{F}}^r,\hat{\mathcal{F}}^d,\mathcal{F}^*,\mathcal{F}^{*r},\mathcal{F}^{*d},\hat{\mathcal{F}}^{*r},\hat{\mathcal{F}}^{*d},\mathcal{M},\mathcal{M}^r,\mathcal{M}^d,\hat{\mathcal{M}}^r,\hat{\mathcal{M}}^d\}$ that satisfy the equations (3)-(17) and policy functions $\{\Pi,\Pi^r,\Pi^d,\mathcal{B},\mathcal{B}^r,\hat{\mathcal{B}}^r,\mathcal{D},\mathcal{G},\mathcal{G}^r,\mathcal{G}^d,\hat{\mathcal{G}}^r,\hat{\mathcal{G}}^d\}$ that satisfy the conditions (1)-(2), (4)-(5), (8)-(11), (14)-(23). The functions $\{\Pi^r,\Pi^d\}$ furthermore solve the policy problems of the central bank (6)-(7) and the functions $\{\hat{\mathcal{B}}^r,\mathcal{D},\hat{\mathcal{G}}^r,\hat{\mathcal{G}}^d\}$ solve the policy problems of the fiscal authority (3), (12)-(13).*

3 Policy Trade-Offs

Before moving to the quantitative analysis, it is helpful to first take a look at the first-order conditions for the fiscal authority and the central bank to understand the forces that drive policy making in the model. Interior solutions to the public policy problems then satisfy the Euler equations

$$\begin{aligned}
0 = \; & \theta u_g(g)\,\Delta_q \\
& -\mu\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\theta u_g(g')\,\Delta'_\lambda-\Delta'_\theta\frac{\partial\Pi^r(b',\tau')}{\partial b'}\right] \\
& +(1-\mu)\,\beta\left(\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[u_g(g')\,\frac{\partial\mathcal{G}^r(b',\tau')}{\partial b'}-\psi_\pi(\pi')\frac{\partial\Pi^r(b',\tau')}{\partial b'}\right]+\Delta'_{\mathcal{F}^*}\frac{\partial\hat{\tau}(b')}{\partial b'}f(\hat{\tau}(b')\,|\tau)\right) \\
& -\mu\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\theta u_g(g')\,\Delta'_q\frac{\partial\mathcal{B}^r(b',\tau')}{\partial b'}\right] \\
& +(2\mu-1)\,\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\beta\mathbb{E}_{\tau''|\tau',\tau''\geq\hat{\tau}(b'')}\left[\theta u_g(g'')\,\Delta''_\lambda-\Delta''_\theta\frac{\partial\Pi^r(b'',\tau'')}{\partial b''}\right]\frac{\partial\mathcal{B}^r(b',\tau')}{\partial b'}\right],
\end{aligned} \tag{24}$$

and

$$\begin{aligned}
0 = \; & \Delta_\alpha+u_g(g)\,\Delta_q\frac{\partial\hat{\mathcal{B}}^r(\pi,b,\tau)}{\partial\pi}+\Delta'_{\mathcal{M}}\frac{\partial\hat{\tau}(b')}{\partial b'}f(\hat{\tau}(b')\,|\tau)\frac{\partial\hat{\mathcal{B}}^r(\pi,b,\tau)}{\partial\pi} \\
& -\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[u_g(g')\,\Delta'_\lambda-\Delta'_\alpha\left(\frac{\partial\Pi^r(b',\tau')}{\partial b'}-\frac{\frac{\partial\mathcal{B}^r(b',\tau')}{\partial b'}}{\frac{\partial\hat{\mathcal{B}}^r(\pi',b',\tau')}{\partial\pi'}}\right)\right]\frac{\partial\hat{\mathcal{B}}^r(\pi,b,\tau)}{\partial\pi},
\end{aligned} \tag{25}$$

with

$$
\begin{aligned}
\Delta_\lambda &\equiv \lambda\pi^{-1}+1-\lambda, \\
\Delta_q &\equiv \lambda q_N\left(b',\tau\right)+(1-\lambda)q_R\left(b',\tau\right)+\left(\lambda\frac{\partial q_N\left(b',\tau\right)}{\partial b'}+(1-\lambda)\frac{\partial q_R\left(b',\tau\right)}{\partial b'}\right)b', \\
\Delta_\theta &\equiv \theta u_g\left(g\right)\lambda\pi^{-2}b-\psi_\pi(\pi), \\
\Delta_\alpha &\equiv u_g\left(g\right)\lambda\pi^{-2}b-\alpha\psi_\pi(\pi), \\
\Delta_{\mathcal{X}} &= \mathcal{X}^d\left(\hat{\tau}\left(b\right)\right)-\mathcal{X}^r\left(b,\hat{\tau}\left(b\right)\right), \mathcal{X}\in\{\mathcal{F}^*,\mathcal{M}\}.
\end{aligned}
$$

Condition (24) characterizes the optimal borrowing decision of the fiscal authority, whereas (25) is the optimality condition for the inflation rate set by the central bank.[21]

As a benchmark, it is useful to first look at the optimality conditions

$$
\begin{aligned}
u_g\left(g\right)\Delta_q &= \beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[u_g\left(g'\right)\Delta'_\lambda\right], &\quad (26)\\
u_g\left(g\right)\lambda\pi^{-2}b &= \psi_\pi(\pi), &\quad (27)
\end{aligned}
$$

which characterize the optimal borrowing and inflation decisions for a benevolent government that is in charge of setting monetary and fiscal policy without commitment. These conditions also apply when the fiscal authority and the central bank both are benevolent and jointly choose fiscal and monetary policy.

The government wants to trade non-state contingent bonds to smooth the impact of fiscal shocks on public consumption (see condition (26)). Note that conditional expectations $\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\cdot\right]$ are taken with respect to repayment states only, where the function $\hat{\tau}\left(b\right)$ denotes the default threshold, i.e. the lowest revenue value τ that is consistent with repayment for given debt b: $\mathcal{F}^r\left(b,\hat{\tau}\left(b\right)\right)=\mathcal{F}^d\left(\hat{\tau}\left(b\right)\right)$. Only in the case of repayment does today's borrowing decision affect outcomes in the subsequent period. In case the fiscal authority decides to default, policies are independent of debt. The marginal revenues obtained by borrowing more today are given by Δ_q. Due to lack of commitment, they do not equal average revenues $\lambda q_N\left(b',\tau\right)+(1-\lambda)q_R\left(b',\tau\right)$. The reason for this is that bond prices respond to the amount of borrowing because expected inflation and the probability of default depend on next period's debt position b'. This effect is captured by the derivatives $\partial q_N\left(b',\tau\right)/\partial b'$ and $\partial q_R\left(b',\tau\right)/\partial b'$ and is internalized by the fiscal

[21]The derivation of these conditions can be found in Appendix A.1. It requires that the policy and value functions in the model are differentiable with respect to the debt position. Note that, following Cuadra and Sapriza (2008), the first-order conditions are only derived and presented here to illustrate the policy trade-offs in a transparent way. The numerical algorithm used for the quantitative analysis does however not build on the first-order conditions and extends solution methods proposed by Hatchondo, Martinez, and Sapriza (2010) (see Appendix A.2 for details).

authority when choosing end-of-period debt b'.

In a stationary Markov-perfect equilibrium, current and future inflation rates are governed by the same policy functions, reflecting that, in each period, inflation is chosen in the same way, given the aggregate state. For the current period, condition (27) depicts the trade-off involved when setting the optimal inflation rate without commitment. When the government inherits positive nominal debt λb, it wants to reduce real debt payments to free resources for public spending (LHS). The optimal inflation rate equates these marginal benefits of inflation to the marginal costs of inflation $\psi_\pi(\pi)$. Since the government optimizes sequentially, it does not internalize that an increase in π additionally affects the nominal bond price in the previous period in an adverse way. The failure to internalize this effect is the source of the time-inconsistency problem of monetary policy in the model. As the temptation to raise inflation increases with the nominal debt position λb, expected inflation is an increasing function of end-of-period debt b'. This implies that, even in the absence of sovereign risk, the elasticity of the nominal bond price schedule with respect to b' is negative, which tends to discourage the government from borrowing and impedes its ability to respond to (adverse) fiscal shocks by issuing bonds.

Although nominal debt introduces a time-inconsistency problem that can increase the cost of borrowing, it also has potential benefits. When only non-state contingent bonds can be issued, the debt contract does not specify future debt payments conditional on future fiscal shocks. While the fiscal authority has the discrete option to adjust debt payments ex post via outright default, inflation offers a much more flexible way of adjusting payments in response to fluctuating tax revenues, making nominal debt a potentially useful hedge against bad fiscal shocks.[22] This hedging property of nominal government debt is captured by the RHS of the Euler equation (26). When only real debt is issued ($\lambda = 0$), the (marginal) debt payment that the fiscal authority will have to make in the next period in case it decides to honor its obligations Δ'_λ does not change with the realization of τ'. By contrast, when the public debt portfolio involves nominal debt ($\lambda > 0$), real payments (negatively) depend on future inflation π'. Since the government will tend to increase inflation in response to adverse fiscal shocks, i.e. when τ is low and $u_g(g)$ is high, the effective debt payment will decline exactly when public resources are scarce. Of course, this state-contingency of real debt payments will be anticipated by rational investors, who demand to be compensated for this inflation risk, and therefore comes at a cost.

Now consider the case without political frictions ($\theta = \mu = 1$) but with disagreement between the

[22] The hedging benefit of nominal government debt is discussed in detail by Bohn (1988). Schmitt-Grohé and Uribe (2004) study the role of inflation as a shock absorber in the context of a New Keynesian model. The hedging benefit of long-term debt relative to short-term debt is highlighted by Arellano and Ramanarayanan (2012) for a sovereign default model with real debt only.

fiscal authority and the central bank ($\alpha \neq 1$). In this case, the first-order condition for the fiscal authority is given by

$$u_g(g)\,\Delta_q = \beta \mathbb{E}_{\tau'|\tau,\tau' \geq \hat{\tau}(b')} \left[u_g(g')\,\Delta'_\lambda - \Delta'_\theta \frac{\partial \Pi^r(b',\tau')}{\partial b'} \right], \tag{28}$$

whereas the optimality condition for the central bank is given by (25).

The expressions Δ_α and Δ_θ measure the net marginal gains of inflation from the perspective of the central bank and the fiscal authority, respectively. If the fiscal authority and the central bank agree on the optimal inflation rate ($\alpha = 1/\theta = 1$), $\Delta_\alpha = \Delta_\theta = 0$ as well as (27) hold. If there is however disagreement about the optimal inflation rate ($\alpha \neq 1/\theta$), $\Delta_\alpha \neq \Delta_\theta$ holds and the two authorities use their policy instruments to strategically manipulate the policies chosen by the other authority. By comparing (28) to (26), one can see that disagreement about future inflation - as measured by Δ'_θ - introduces a wedge into the first-order condition (26), distorting public consumption smoothing.[23] The size of this wedge depends on $\partial \Pi^r(b',\tau')/\partial b'$, i.e. on the response of future inflation to an increase in borrowing. As argued above, this derivative tends to be positive which implies that if, from the perspective of the fiscal authority, the expected marginal benefits of inflation exceed the respective marginal costs ($\Delta'_\theta > 0$), the fiscal authority has an incentive to increase borrowing to reduce the gap Δ'_θ. Similarly, the central bank has an incentive to use inflation to distort the borrowing decision of the fiscal authority (see condition (25)). In contrast to (27), the inflation choice now also involves intertemporal considerations because the central bank has an incentive to influence the borrowing decision of the fiscal authority in the current period via the inflation rate.

When the two policy authorities have different objectives, one motivation for the central bank to distort the borrowing decision is to affect the default decision in the subsequent period. This motive is captured by the third term on the RHS of equation (25). The wedge $\Delta'_{\mathcal{M}}$ measures the magnitude and direction of the central bank's disagreement with the fiscal authority's default decision, whereas the derivative $\partial \hat{\tau}(b')/\partial b'$ measures how the default decision responds to changes in debt issuance. As will be shown in the next section and consistent with Arellano (2008), this derivative tends to be positive, i.e. default is more attractive for higher debt levels. This property also implies that the real bond price declines with debt issued, i.e. $\partial q_R(b',\tau)/\partial b' \leq 0$.

If, in addition to disagreement between the fiscal authority and the central bank ($\alpha \neq 1/\theta$), there are also political frictions ($\theta > 1$, $\mu < 1$), the first-order condition for the fiscal authority changes from (28) to (24). It can be thought of as a version of the Euler equation derived in Cuadra and Sapriza (2008),

[23] Similar wedges can be found in Niemann (2011) and Martin (2015).

extended to incorporate monetary-fiscal policy interactions as in Niemann (2011) or Martin (2015). As in Cuadra and Sapriza (2008), the existence of political disagreement ($\theta > 1$) and turnover risk ($\mu < 1$) affects the borrowing decision of the fiscal authority via three effects (see Cuadra and Sapriza, 2008, p. 84). The first effect is captured by the second term on the RHS of (24) and is referred to as ”impatience effect” by Cuadra and Sapriza (2008). Because the incumbent party only stays in office with probability μ, it discounts the expected marginal costs of debt repayment more than without turnover risk. As a result, it is encouraged to front-load public consumption by borrowing more in the current period.

The third term on the RHS of (24) displays what Cuadra and Sapriza (2008) call the ”disagreement effect”. With probability $1-\mu$, the opposite party takes over office in the subsequent period. In this case, the implemented fiscal policy will be different from what the party currently in office would prefer since it will have a lower marginal valuation of the public good when it is not in power anymore. In the current period, the incumbent party then uses borrowing as a strategic device to manipulate future fiscal policy set by the opposite political party in case there is a change in power. More specifically, the incumbent party increases borrowing (or reduces savings) to leave less financial resources for the other party to spend on public spending in the next period. With political frictions, the party not in office also tends to disagree with the incumbent party's default decision as measured by the wedge $\Delta'_{\mathcal{F}^*}$.[24]

The last two terms on the RHS of (24) capture the third effect by which political frictions affect the fiscal authority's borrowing decision. It shows that there is not only disagreement about future public spending - as captured by the ”disagreement effect” above - but also about future borrowing. While the role of this effect for the borrowing decision of today's incumbent party is not clear ex ante, the two other effects tend to lead the fiscal authority to borrow more relative to a scenario without political frictions.

Having nominal and real debt in the model allows me to highlight the different implications that a more conservative central bank and a lower nominal debt share have for public policy. Although both of these changes tend to reduce the temptation to lower the real debt burden via inflation, they do so in different ways. Whereas λ affects the gains of inflation, α impacts on the costs of inflation as perceived by the central bank. Obviously, setting $\alpha \to \infty$ or $\lambda = 0$ delivers the same allocation with full price stability since monetary policy does not respond to the debt position at all. For the remaining cases $\lambda \in (0,1]$ and $\alpha \in [0,\infty)$ however, public policy is affected differently.

To see this, consider the optimality conditions (26) and (27) associated with the benevolent govern-

[24]The Euler equation presented by Cuadra and Sapriza (2008) does not feature this disagreement effect related to the default decision since the authors assume that their model's random variable (output) is drawn from a probability distribution with discrete support. This is however at odds with the assumption of a differentiable equilibrium that the authors make to derive the Euler equation.

ment as the starting point. If monetary policy is delegated and $\alpha > 1$ holds, the temptation to use inflation for a given debt position declines. This effect comes however at the expense of disagreement between the (benevolent) fiscal authority and the monetary conservative central bank about the cost of inflation and thus about the optimal inflation rate, i.e. $\Delta_\theta > \Delta_\alpha$. This disagreement distorts the borrowing decision of the fiscal authority (see condition (28)) which then feeds back into decision of the central bank (see condition (25)). By contrast, a reduction in the nominal debt share λ reduces the incentive to resort to inflation by reducing the gains of inflation as perceived by both authorities, $u_g(g)\lambda\pi^{-2}b$. As a result, a reduction in λ does not have the negative side effects associated with an increase in α. With political frictions ($\theta > 1$), there always is disagreement between the fiscal authority and the central bank about the inflation rate for $\alpha \neq \alpha_\theta$ such that the differences between an increase in α and a decrease in λ are not as clear.

4 Quantitative Analysis

After having discussed the main forces of the model in the previous section, this section presents a quantitative analysis of the model's properties when the fiscal authority may default on its debt. Section 4.1 is concerned with model specification. Section 4.2 presents simulation results for different model versions. Section 4.3 evaluates the welfare properties of different monetary policy regimes. Appendix A.2 provides computational details about the numerical solution of the model.

4.1 Model Specification

This section discusses how the model is specified.

4.1.1 Functional Forms

For the objective functions, an iso-elastic utility function

$$u(g) = \begin{cases} \frac{g^{1-\gamma}}{1-\gamma} & \text{if } \gamma \neq 1 \\ \ln g & \text{if } \gamma = 1 \end{cases}$$

and quadratic inflation costs

$$\psi(\pi) = \frac{\chi}{2}(\pi - 1)^2,\ \chi > 0,$$

are used.[25]

Following Arellano (2008), I adopt an asymmetric specification for the resource costs of default:

$$\phi(\tau) = \max\{0, \tau - \tilde{\tau}\}.$$

This default cost specification implies that the resource costs of default increase overproportionally with tax revenues. As a result, default is particularly attractive in bad states, i.e. when tax revenues are low, which is a feature that is both intuitive and empirically plausible (see Tomz and Wright, 2007).

Finally, tax revenues follow a log-normal AR(1)-process:

$$\tau_t = \tau_{t-1}^{\rho} \exp(\sigma\varepsilon_t), \; \varepsilon_t \overset{i.i.d.}{\sim} \mathcal{N}(0,1).$$

4.1.2 Parameters

The model is calibrated under the assumption that there is no central bank independence and monetary policy is directly set by the party currently in office, which is not benevolent due to $\theta > 1$ and $\mu < 1$. Section 4.2 will then look at how different monetary policy regimes affect public policy relative to this scenario. In particular, I will consider α-values relative to $\alpha_\theta = 1/\theta$. If $\alpha = \alpha_\theta$, the central bank and the fiscal authority put the same relative weights on $u(g)$ and $\psi(\pi)$, such that the main source of disagreement between the two authorities is the present bias of the fiscal authority.

One model period corresponds to one quarter. The parameters are set as follows. For γ, a standard value of 2 is used. The value for the real risk-free rate $r_f = 0.017$ is taken from Arellano (2008). The probability of reentry δ is set to 0.1 as in Aguiar and Gopinath (2006). Following Cuadra and Sapriza (2008), the probability of remaining in power μ is set to 0.9. For the inflation cost parameter χ, the default cost parameter $\tilde{\tau}$ and the disagreement parameter θ, I use values of 1.53, 0.988 and 2.75 to match an average debt-to-tax revenue ratio of roughly 5%, an annual default probability of 1% and an average annual inflation rate of 20.68%. Loungani and Swagel (2001) list average annual inflation rates for 53 developing economies for the time period 1964-1998, documenting an average inflation rate of 16.4%. The focus of this paper is on economies that experience persistently high inflation rates. When only economies that experienced inflation rates above 10 percent and below 50 percent are considered, the average inflation rate goes up to 20.68% for the sample.[26] An average annual default probability of 1%

[25] This inflation cost function implies that positive ($\pi > 1$) and negative ($\pi < 1$) deviations from full price stability are costly.

[26] There are 21 countries left in their sample that fit these criteria. Only Argentina (78.4%), Brazil (142.2%) and Peru (60.4%) experienced inflation rates above 50%.

	Baseline	$\alpha = \alpha_\theta$	$\alpha = 2\alpha_\theta$	$\alpha = 3\alpha_\theta$	$\alpha = 10\alpha_\theta$
Avg. default prob. (annual)	0.0087	0.0085	0.0155	0.0175	0.0192
Mean(b/τ)	0.0531	0.0519	0.0654	0.0684	0.0708
Mean($\pi - 1$) (annual)	0.2095	0.2116	0.1322	0.0930	0.0291
Std(g)/Std(τ)	1.1041	1.0957	1.1956	1.2262	1.2614
Std(π)/Std(τ)	1.3399	1.3118	1.2152	0.9516	0.3263
Welfare measure ω (in %)	-	0.0005	0.0523	0.0789	0.1051

Table 1: Selected model statistics

means that the economy defaults once in 100 years. This value implies that the government is not a notorious serial defaulter but that it defaults frequently enough for sovereign risk to matter for the public borrowing conditions. For the nominal debt share, I use an empirically plausible value of $\lambda = 0.58$.[27] For the tax revenue process, I set the persistence parameter ρ to 0.9 and calibrate the shock variance to match the volatility of log-government spending for Mexico, which is a typical emerging economy, resulting in the parameter value $\sigma = 0.022$.[28]

The household discount factor β is set to the investor discount factor $1/(1+r_f)$, implying that there is no long-run borrowing motive for the economy that is driven by its impatience relative to foreign investors. Most quantitative sovereign default models use discount factors that are much lower than $1/(1+r_f)$.[29] In these models, a high degree of impatience is needed to make the government accumulate debt levels that are sufficiently high to render default an attractive policy option. Such low discount factors can be motivated by referring to political economy distortions as modeled by Cuadra and Sapriza (2008). For a strictly positive analysis, it might not be of first-order importance to explicitly model the source of the government's impatience. A welfare analysis as performed in this paper should however consider the possibility that a government borrows due to political frictions and not simply because its citizens are more impatient than foreign investors. In Section 4.4, I will consider alternative calibrations with $\beta < 1/(1+r_f)$.

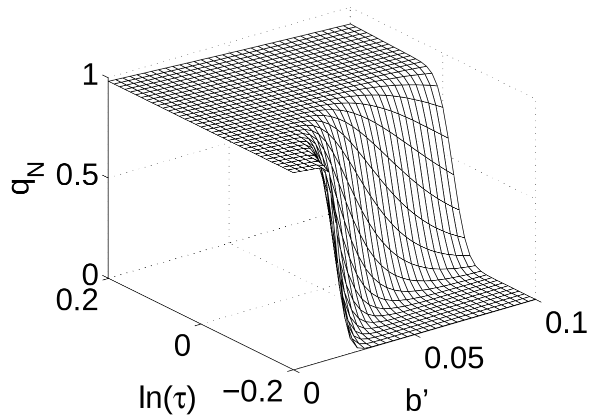
4.2 Simulation Results

The simulation results are shown in Table 1. It presents average statistics calculated for a panel of 2500 simulated economies with 2000 periods each, where the first 500 observations of each sample were

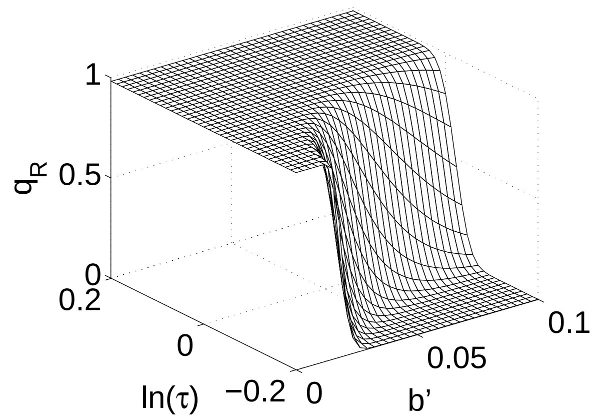
[27] Du and Schreger (2015) list the share of external government debt that is issued in local currency for 14 emerging economies. In 2012, the average share for these economies was 57.99%.

[28] I use the quarterly time series for log real government expenditure provided by Cuadra, Sanchez, and Sapriza (2010). The time series have been seasonally adjusted via EViews' multiplicative X-12 routine and filtered via the Hodrick-Prescott filter with a smoothing parameter of 1600. The calculated standard deviation for government expenditure is 0.03.

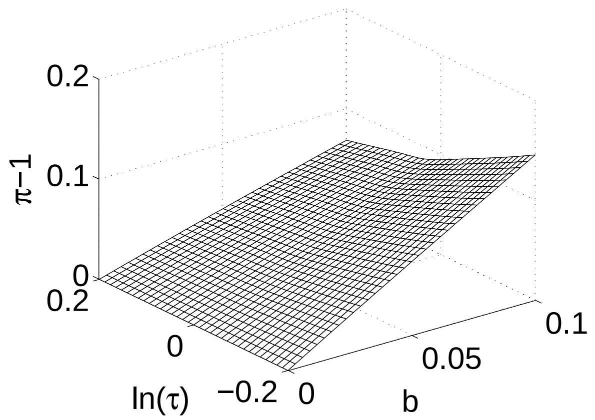
[29] For instance, Aguiar and Gopinath (2006) consider a quarterly discount factor of 0.8.



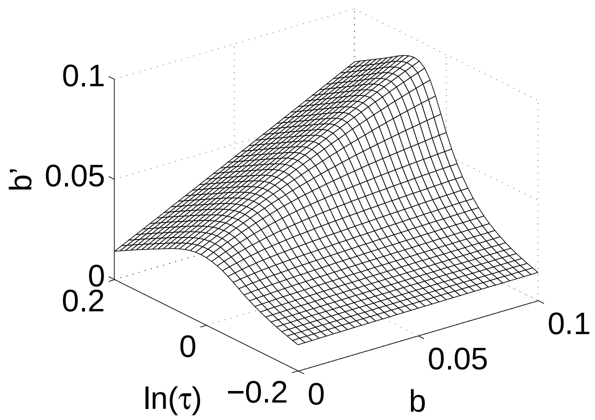
(a) Bond price schedule (nominal)



(b) Bond price schedule (real)



(c) Inflation rate



(d) Borrowing

Figure 1: Bond price schedules and policy functions for inflation and borrowing in the repayment case ($\alpha = \alpha_\theta$)

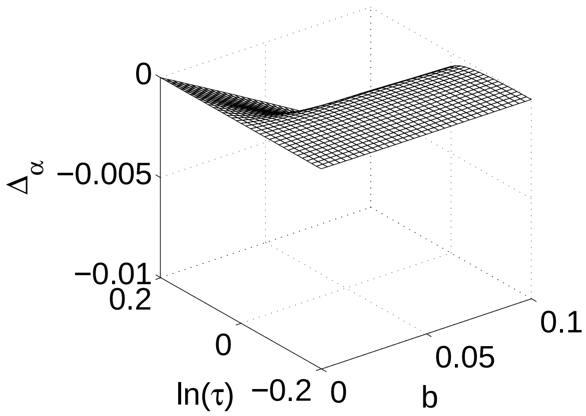
discarded to eliminate the impact of initial conditions. The time series are filtered using the Hodrick-Prescott filter and a smoothing parameter of 1600. The baseline scenario corresponds to the model version without central bank independence. The main observations are that a higher degree of monetary conservatism α tends to result in higher average debt and more frequent default events as well as a decline in inflation. In addition, a more conservative central bank will also lead to more stable inflation but more volatile fiscal policy. In the remainder of this section, different channels that might drive these results are discussed in detail.

Bond Price Elasticity Channel In a Markov-perfect equilibrium, the borrowing decision of the fiscal authority depends on how elastic the bond price schedules $q_N(b', \tau)$ and $q_R(b', \tau)$ respond to changes in the level of future debt b' (see Figure 1). The bond price elasticities reflect the incentive to use inflation or default to reduce the real debt burden. As in Arellano (2008), a default is more attractive in adverse states, i.e. when tax revenues are low and/or debt is high. As a result, for such combinations the bond price schedules are lower and more responsive to debt issuance, reflecting an increase in the probability of default. Expected inflation is also higher in this case but default risk is the dominant force for bond pricing and therefore the borrowing decision. This changes when tax revenues are high and sovereign risk is low. Now, the nominal bond price schedule mostly reflects inflation risk while the real bond price hardly responds to b' at all (for low and intermediate borrowing levels). As debt increases, monetary policy will increase inflation to reduce the real debt burden, not internalizing how this choice affects borrowing costs in the previous period. When the degree of monetary conservatism is increased, the central bank is less tempted to use inflation to adjust debt payments which translates into a nominal bond price schedule that is less responsive to the level of borrowing. This in turn encourages the fiscal authority to borrow more in good times, leading to higher average debt, a decline in average inflation and an increase in the default frequency since the incentive to default increases with debt.[30][31]

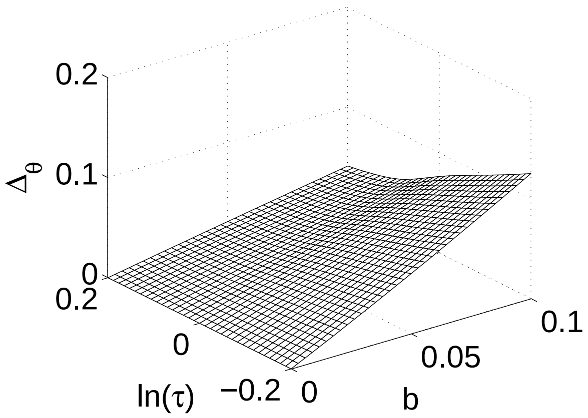
Disagreement Channel As discussed in Section 3, disagreement between the fiscal authority and the central bank about the marginal gains and costs of inflation might also matter for the fiscal authority's borrowing behavior. Figure 2 depicts the terms Δ_α and Δ_θ for different degrees of monetary conservatism. The term Δ_α measures the net marginal gains of inflation from the central bank's point of view. It is negative and decreasing in the degree of monetary conservatism. As shown by condition (25), when Δ_α deviates from zero, where the central bank would equalize the marginal gains and costs of inflation, the central bank wants to manipulate the spending and borrowing decisions of the fiscal authority. More specifically, when Δ_α is negative, the central bank deliberately chooses an inflation rate that is "too high" to relax the government budget and make the fiscal authority overborrow less. By contrast, the term Δ_θ, which reflects the net marginal gains of inflation from the perspective of the fiscal authority, is positive and increasing in debt. As shown by condition (24), a positive value for Δ_θ will tend to encourage the fiscal policy maker to borrow more since inflation positively responds to debt, i.e. $\partial\Pi^r(b,\tau)/\partial b > 0$. This way, the fiscal authority tries to force the central bank to implement an inflation rate that is higher and thus closer to its preferred one. When the degree of monetary conservatism is increased, the term

[30] Aguiar, Amador, Farhi, and Gopinath (2014) make a related argument in a model of a small open (endowment) economy without policy interaction between a fiscal and a monetary authority and (equilibrium) default. They also highlight the link between the incentive to use inflation, the elasticity of the nominal interest rate and the evolution of debt. Niemann (2011) also finds that increased monetary conservatism leads to increased debt accumulation in a model where the fiscal authority is myopic, cannot default and does not internalize its effect on future policies.

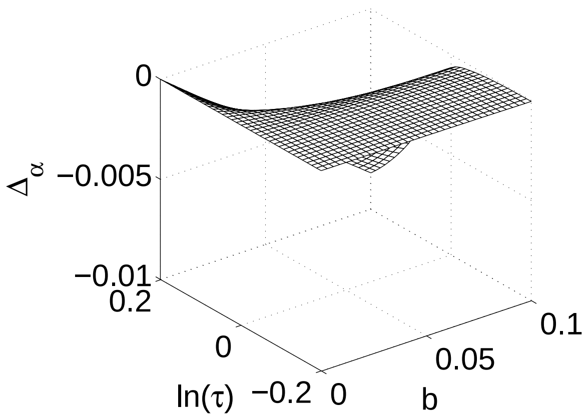
[31] Note that it is not obvious that an increase in α necessarily reduces average inflation since it also increases the average debt burden which then increases the marginal gains of inflation on average.



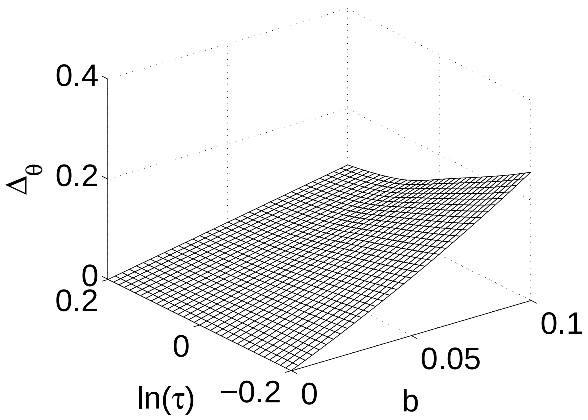
(a) Δ_α $(\alpha = 2\alpha_\theta)$



(b) Δ_θ $(\alpha = 2\alpha_\theta)$



(c) Δ_α $(\alpha = 10\alpha_\theta)$

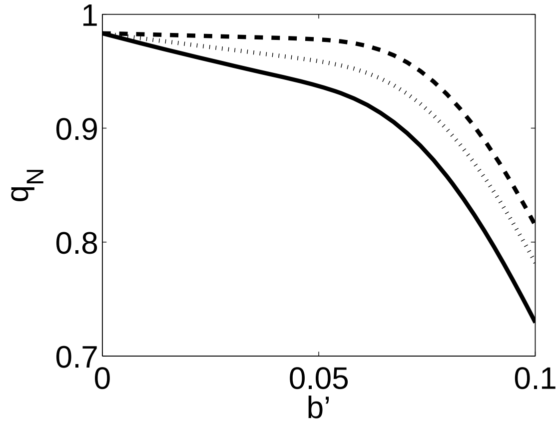


(d) Δ_θ $(\alpha = 10\alpha_\theta)$

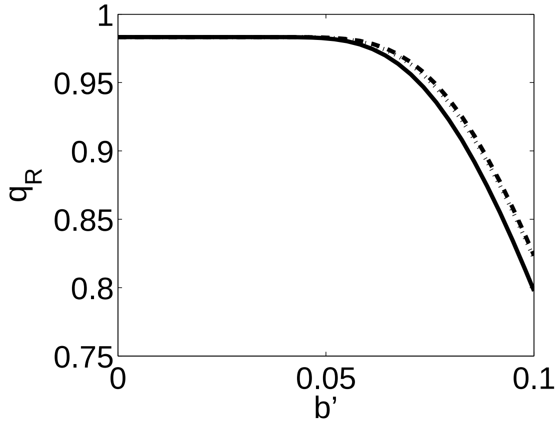
Figure 2: Disagreement terms for the central bank (Δ_α) and the fiscal authority (Δ_θ) for different degrees of monetary conservatism and conditional on repayment

Δ_θ increases for given (b, τ). However, the response of the inflation rate to the level of debt declines when α goes up (see Figure 3). As a consequence, the combined expression $\Delta_\theta (\partial \Pi^r (b, \tau) / \partial b)$ does not respond to changes in the degree of monetary conservatism very much. While the disagreement channel is present and affecting the borrowing decision, it is hence not as important as the bond price elasticity channel when it comes to evaluating the impact of having a tougher central bank on fiscal policy.

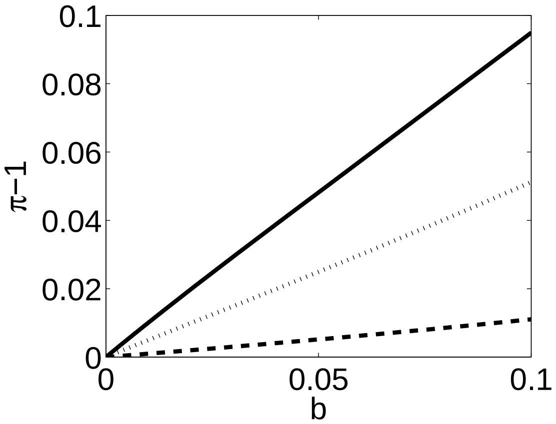
Vulnerability to a Debt Crisis How does monetary conservatism affect the economy's vulnerability to a sovereign debt crisis? When the central bank is more conservative, one might expect that - for a given state (b, τ) - it will be more attractive for the fiscal authority to default since the central bank is less willing to reduce the real debt burden via inflation. However, this reasoning ignores that the fiscal authority might - ceteris paribus - also face lower nominal interest rates for a given amount of debt



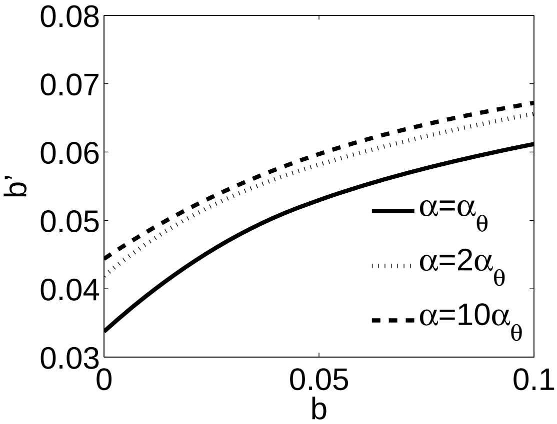
(a) Bond price schedule (nominal)



(b) Bond price schedule (real)



(c) Inflation rate



(d) Borrowing

Figure 3: Bond price schedules and policy functions for inflation and borrowing in the repayment case for different degrees of monetary conservatism ($\tau = \mathbb{E}[\tau]$)

issuance because the central bank's tougher monetary policy stance tends to reduce expected inflation. These improved borrowing conditions might then encourage the fiscal authority not to default, reducing the likelihood of such an event for a given amount of debt. In addition, as argued by Aguiar, Amador, Farhi, and Gopinath (2014), when monetary policy is less willing to raise inflation, the relative gains of default decline since the drop in inflation would be smaller, reducing the incentive to default. Figure 3 shows that the improvement in borrowing conditions indeed reduces the attractiveness of default. It depicts the bond price schedules as well as the inflation and borrowing policy functions for different degrees of monetary conservatism, given that tax revenues are at their unconditional mean. The changes in the probability of default can be observed by looking at the real bond price schedule which increases when the degree of monetary conservatism goes up. While monetary conservatism reduces the incentive to default for a given amount of debt, the economy still experiences more frequent default events because of the bond price elasticity channel described earlier in this section, which increases the average debt burden and as a result the fiscal authority's incentive to default.

Inflation as a Shock Absorber The degree of monetary conservatism also has important implications for the fiscal authority's ability to smooth government spending across states. By decreasing the central bank's willingness to use inflation to adjust real debt payments in response to fiscal shocks, a higher degree of monetary conservatism leads to more volatile fiscal policy since a more stable inflation rate implies a reduced role for inflation as a shock absorber. In addition, when α is higher, a less responsive nominal bond price leads to a higher average debt burden, which in turn increases the likelihood of a debt crisis by making default more attractive. The increase in sovereign risk then raises the volatility of fiscal policy since borrowing becomes more expensive in response to adverse shocks.

4.3 Welfare Analysis

Given the results of the previous section, the welfare effects of increasing the degree of monetary conservatism are not obvious. While a higher value for α has the benefit of lowering the mean and variance of inflation, it also leads to a higher average debt burden and more frequent default events that are associated with temporary periods of costly autarky. In addition, the increased volatility of public spending will tend to have an adverse impact on household welfare as well.

To quantify the welfare implications of central bank independence, I calculate the welfare measure ω. It is the percentage increase in public consumption that households in an economy without central bank independence need to be given in each period to achieve the same welfare as in the respective economy with monetary conservatism of degree α, where household welfare is given by

$$\mathcal{U} = \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t U\left(g_t, \pi_t\right) \right],$$

with

$$U\left(g_t, \pi_t\right) = u\left(g_t\right) - \psi\left(\pi_t\right).$$

Table 1 shows that the computed values for ω are positive and increasing in α, with values ranging from almost zero ($\alpha = \alpha_\theta$) to 0.1% ($\alpha = 10\alpha_\theta$).[32] The benefits of monetary conservatism (lower and more stable inflation) thus outweigh the associated costs (more average debt, less average supply of the public

[32]The unconditional expectation of discounted life-time utility $\mathcal{U}$ is calculated by computing the sum of discounted simulated utilities for 2000 periods and taking the average value over 2500 samples, where the first 500 observations are discarded for each sample to reduce the role of initial conditions.

	$\alpha = \bar{\alpha}$	$\alpha = 2\bar{\alpha}$	$\alpha = 3\bar{\alpha}$	$\alpha = 10\bar{\alpha}$
$\theta = 1,\, \mu = 1$	0	-0.0239	-0.0261	-0.0459
$\theta > 1,\, \mu = 1$	0	0.0369	0.0665	0.0906
$\theta > 1,\, \mu < 1$	0.0008	0.0484	0.0678	0.0945

Table 2: Welfare measure ω (in %) for different degrees of political frictions

good, more volatile fiscal policy), leading to a small net welfare gain. The welfare analysis implies that the optimal degree of monetary conservatism involves a central bank that does not respond to the state of the economy and implements a constant inflation rate ($\alpha \to \infty$). This result is consistent with the findings of Nuño and Thomas (2015) who also show that the gains of eliminating the time-inconsistency problem related to inflation dominate the costs of having a less flexible monetary policy. Here however, the superiority of such an unresponsive monetary policy regime even holds when the fiscal authority is not benevolent and subject to political economy considerations.

4.4 The Role of Political Frictions

To understand the importance of the political economy distortions for the welfare results, I will now consider two model versions where political frictions are either completely absent ($\theta = \mu = 1$) or partially absent ($\theta > 1, \mu = 1$). Since the model requires political disagreement ($\theta > 1$) and turnover risk ($\mu < 1$) to generate a deficit bias, adjustments are needed to have a persistent borrowing motive in these model versions. To achieve this, I make the standard assumption that the small open economy is impatient relative to foreign investors, i.e. $\beta < 1/(1+r_f)$. The parameters β, τ^d and χ are again chosen to match the same long-run values for average debt, inflation and the frequency of default as in the baseline scenario without delegated monetary policy. The values are $\beta = 0.927$, $\tau^d = 0.982$, as well as $\chi = 0.556$ for the model version without political frictions and $\chi = 1.530$ for the one where disagreement between the political parties is still present. The remaining model parameters from Section 4 are kept unchanged.

The welfare results are presented in Table 2. The important observation is that the welfare measure is negative and decreasing in α for the model version without political frictions. From the perspective of the households, it is hence welfare-reducing to have a monetary conservative central bank when the fiscal authority is benevolent. If there is disagreement between the political parties but no turnover risk, the welfare measure remains positive and increasing in α. When assessing the desirability of central bank independence it is thus important why the government chooses a high inflation rate. If the initial ("pre-reform") inflation rate is high but because of society's preferences and not due to the preferences of the incumbent party, the economy is better off without central bank independence. Relative to the welfare improvements found for the model version from Section 4 ($\theta > 1, \mu < 1$), the welfare gains for the model without turnover risk but with political disagreement are only slightly higher. The motive to issue debt thus is not as important for the welfare results as the motive to use inflation.

4.5 Robustness

To be written.

5 Conclusion

This paper has studied the effectiveness and desirability of monetary conservatism in a quantitative model that accounts for three frictions that are important for many emerging economies: (i) incomplete financial markets, (ii) default risk, and (iii) political distortions. In the model, fiscal policy is set by a fiscal authority that cannot commit to future policy and exhibits a deficit bias. Monetary policy is chosen by a central bank that also lacks commitment and might care more about inflation than the fiscal authority and society. The paper has shown that the delegation of monetary policy to an inflation conservative central bank successfully reduces the mean and variance of inflation but is associated with a higher average debt burden, more frequent debt crises and more volatile fiscal policy. A welfare analysis has shown that the benefits of lower and more stable inflation can outweigh the costs associated with the adverse effects on fiscal policy depending on the degree of political distortions in the economy.

References

Adam, K., and R. Billi (2008): "Monetary Conservatism and Fiscal Policy," *Journal of Monetary Economics*, 55(8), 1376–1388. 2, 3, 9

Aguiar, M., and M. Amador (2011): "Growth in the Shadow of Expropriation," *Quarterly Journal Of Economics*, 126(2), 651–697. 2, 6, 7

——— (2014): "Sovereign Debt," in *Handbook of International Economics*, ed. by E. Helpman, K. Rogoff, and G. Gopinath, vol. 4, chap. 11, pp. 1243–1277. Elsevier, Amsterdam. 3

Aguiar, M., M. Amador, E. Farhi, and G. Gopinath (2013): "Crisis and Commitment: Inflation Credibility and the Vulnerability to Sovereign Debt Crises," Mimeo, Princeton University. 4, 5, 9

——— (2014): "Sovereign Debt Booms in Monetary Unions," *American Economic Review: Papers and Proceedings*, 104(5), 101–106. 2, 7, 24, 26

——— (2015): "Coordination and Crisis in Monetary Unions," *Quarterly Journal of Economics*, 130(4), 1727–1779. 4, 5

Aguiar, M., and G. Gopinath (2006): "Defaultable Debt, Interest Rates and the Current Account," *Journal of International Economics*, 69(1), 64–83. 7, 8, 21, 22

Aisen, A., and F. Veiga (2005): "Does Political Instability Lead to Higher Inflation? A Panel Data Analysis," IMF Working Papers 05/49. 6

Alesina, A., and G. Tabellini (1990): "A Positive Theory of Fiscal Deficits and Government Debt," *Review of Economic Studies*, 57(3), 403–414. 7

Araujo, A., M. L., and R. Santos (2013): "Welfare Analysis of Currency Regimes with Defaultable Debts," *Journal of International Economics*, 89(1), 143–153. 4

Arellano, C. (2008): "Default Risk and Income Fluctuations in Emerging Economies," *American Economic Review*, 93(3), 690–712. 3, 7, 8, 11, 18, 21, 24, 38

Arellano, C., and A. Ramanarayanan (2012): "Default and the Maturity Structure in Sovereign Bonds," *Journal of Political Economy*, 120(2), 187–232. 17

Bachetta, P., E. P., and E. van Wincoop (2015): "Self-Fulfilling Debt Crises: Can Monetary Policy Really Help?," NBER Working Paper No. 21158. 4

BARRO, R., AND D. GORDON (1983a): "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, 94(4), 589–610. 1

——— (1983b): "Rules, Discretion and Reputation in a Model of Monetary Policy," *Journal of Monetary Economics*, 12(1), 101–121. 10

BATTAGLINI, M., AND S. COATE (2008): "A Dynamic Theory of Public Spending, Taxation, and Debt," *American Economic Review*, 98(1), 201–236. 6

BOHN, H. (1988): "Why Do We Have Nominal Government Debt?," *Journal of Monetary Economics*, 21(1), 127–140. 17

CALVO, G., AND P. GUIDOTTI (1992): "Optimal Maturity of Nominal Government Debt: An Infinite-Horizon Model," *International Economic Review*, 33(4), 895–919. 5

CAO, D., AND I. WERNING (2016): "Dynamic Savings Choices with Wealth-Dependent Time Inconsistency," NBER Working Paper No. 22007. 7

CARSTENS, A., AND L. JÁCOME (2005): "Latin American Central Bank Reform: Progress and Challenges," IMF Working Papers 05/114. 1

CHATTERJEE, S., AND B. EYIGUNGOR (2012): "Optimal Maturity of Nominal Government Debt: An Infinite-Horizon Model," *American Economic Review*, 102(5), 2674–2699. 8

——— (2016): "Continuous Markov Equilibria with Quasi-Geometric Discounting," *Journal of Economic Theory*, 163(3), 467–494. 7

CLARIDA, R., J. G., AND M. GERTLER (1999): "The Science of Monetary Policy," *Journal of Economic Literature*, 37(4), 1661–1707. 1

COLE, H., AND T. KEHOE (2000): "Self-Fulfilling Debt Crises," *Review of Economic Studies*, 67(1), 91–116. 4

CORSETTI, G., AND L. DEDOLA (2014): "The Mystery of the Printing Press: Monetary Policy and Self-Fulfilling Debt Crises," Mimeo, Cambridge University. 4

CUADRA, G., J. SANCHEZ, AND H. SAPRIZA (2010): "Fiscal Policy and Default Risk in Emerging Markets," *Review of Economic Dynamics*, 13(2), 452–469. 22

CUADRA, G., AND H. SAPRIZA (2008): "Sovereign Default, Interest Rates and Political Uncertainty in Emerging Markets," *Journal of International Economics*, 76(1), 78–88. 2, 3, 6, 10, 16, 18, 19, 21, 22, 34

DA-ROCHA, J., E. GIMENEZ, AND F. LORES (2013): "Self-Fulfilling Crises with Default and Devaluation," *Economic Theory*, 53(3), 499–535. 4

DU, W., AND J. SCHREGER (2015): "Sovereign Risk, Currency Risk, and Corporate Balance Sheets," Mimeo, Federal Reserve Board. 3, 22

EATON, J., AND M. GERSOVITZ (1981): "Debt with Potential Repudiation: Theoretical and Empirical Analysis," *Review of Economic Studies*, 48(2), 289–309. 6

HATCHONDO, J., L. MARTINEZ, AND H. SAPRIZA (2010): "Quantitative Properties of Sovereign Default Models: Solution Methods Matter," *Review of Economics Dynamics*, 13(4), 919–933. 16, 38, 41, 42

KOCHERLAKOTA, N. (2014): "Central Bank Independence and Sovereign Default," *Financial Stability Review*, 16, 151–154. 2

KRUSELL, P., B. KURUSCU, AND A. SMITH (2002): "Equilibrium Welfare and Government Policy with Quasi-Geometric Discounting," *Journal of Economic Theory*, 105(1), 42–72. 7

KYDLAND, F., AND E. PRESCOTT (1977): "Rules Rather Than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, 85(3), 473–491. 1

LAIBSON, D. (1997): "Golden Eggs and Hyperbolic Discounting," *Quarterly Journal of Economics*, 112(2), 443–478. 7

LOUNGANI, P., AND P. SWAGEL (2001): "Sources of Inflation in Developing Countries," IMF Working Papers 01/198. 21

LUCAS, R., AND N. STOKEY (1983): "Optimal Fiscal and Monetary Policy in an Economy without Capital," *Journal of Monetary Economics*, 12(1), 55–93. 1

MARTIN, F. (2015): "Debt, Inflation and Central Bank Independence," *European Economic Review*, 79, 129–150. 3, 10, 18, 19

NA, S., S. SCHMITT-GROHÉ, M. URIBE, AND V. YUE (2015): "A Model of Twin Ds: Optimal Default and Devaluation," Mimeo, Columbia University. 3

NICOLINI, J. (1998): "More on the Time Consistency of Monetary Policy," *Journal of Monetary Economics*, 41(2), 333–350. 1, 3

NIEMANN, S. (2011): "Dynamic Monetary-Fiscal Interactions and the Role of Monetary Conservatism," *Journal of Monetary Economics*, 58(3), 234–247. 2, 3, 7, 9, 18, 19, 24

NIEMANN, S., P. PICHLER, AND G. SORGER (2013): "Central Bank Independence And The Monetary Instrument Problem," *International Economic Review*, 54(8), 1031–1055. 3, 9, 10, 34

NUÑO, G., AND C. THOMAS (2015): "Monetary Policy and Sovereign Debt Vulnerability," Mimeo, Banco de España. 3, 28

PERSSON, T., AND L. SVENSSON (1989): "Why a Stubborn Conservative Would Run a Deficit: Policy with Time-Inconsistent Preferences," *Quarterly Journal of Economics*, 104(2), 325–345. 7

ROGOFF, K. (1985): "The Optimal Degree of Commitment to an Intermediate Monetary Target," *Quarterly Journal of Economics*, 100(4), 1169–1189. 0, 1, 2, 9

ROTEMBERG, J. (1982): "Sticky Prices in the United States," *Journal of Political Economy*, 90(6), 1187–1211. 5

RÖTTGER, J. (2015): "Monetary and Fiscal Policy with Sovereign Default," Mimeo, University of Cologne. 3

SCHMITT-GROHÉ, S., AND M. URIBE (2004): "Optimal Fiscal and Monetary Policy under Sticky Prices," *Journal of Economic Theory*, 114(2), 198–230. 17

SCHOLL, A. (2016): "The Dynamics of Sovereign Default Risk and Political Turnover," Mimeo, University of Konstanz. 6

SUNDER-PLASSMANN, L. (2014): "Inflation, Default, and the Denomination of Sovereign Debt," Mimeo, University of Copenhagen. 3

TOMZ, M., AND M. WRIGHT (2007): "Do Countries Default in Bad Times?," *Journal of the European Economic Association*, 5(2-3), 352–360. 21

A Appendix

A.1 First-Order Conditions for the Policy Problems

I will first cover the decision problem of the central bank and then derive the first-order condition associated with the fiscal policy problem.[33] Before doing so, I introduce the notation $s \equiv (b, \tau)$ and $\hat{s} \equiv (\pi, s)$.

A.1.1 Euler Equation for the Central Bank

For an interior solution, the first-order condition for the central bank's problem is

$$\frac{\partial \hat{\mathcal{M}}^r(\hat{s})}{\partial \pi} = 0,$$

or

$$u_g(g) \frac{\partial \hat{\mathcal{G}}^r(\hat{s})}{\partial \pi} - \alpha \psi_\pi(\pi) + \beta \left(\mathbb{E}_{\tau'|\tau, \tau' \geq \hat{\tau}(b')} \left[\frac{\partial \mathcal{M}^r(s')}{\partial b'} \right] + \Delta'_{\mathcal{M}} \frac{\partial \hat{\tau}(b')}{\partial b'} f(\hat{\tau}(b') | \tau) \right) \frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi} = 0, \quad (29)$$

with

$$\Delta_{\mathcal{M}} = \mathcal{M}^d(\hat{\tau}(b)) - \mathcal{M}^r(b, \hat{\tau}(b)).$$

For the central bank, the value $\mathcal{M}^r(s)$ satisfies

$$\mathcal{M}^r(s) = u(\mathcal{G}^r(s)) - \alpha \psi(\Pi^r(s)) + \beta \mathbb{E}_{\tau'|\tau} \left[\mathcal{M}(\mathcal{B}^r(s), \tau') \right].$$

Differentiating $\mathcal{M}^r(s)$ with respect to b yields

$$\begin{aligned} \frac{\partial \mathcal{M}^r(s)}{\partial b} &= u_g(g) \frac{\partial \mathcal{G}^r(s)}{\partial b} - \alpha \psi_\pi(\pi) \frac{\partial \Pi^r(s)}{\partial b} \\ &\quad + \beta \left(\mathbb{E}_{\tau'|\tau, \tau' \geq \hat{\tau}(b')} \left[\frac{\partial \mathcal{M}^r(s')}{\partial b'} \right] + \Delta'_{\mathcal{M}} \frac{\partial \hat{\tau}(b')}{\partial b'} f(\hat{\tau}(b') | \tau) \right) \frac{\partial \mathcal{B}^r(s)}{\partial b}. \end{aligned} \quad (30)$$

By using the first-order condition (29) to replace $\beta \left(\mathbb{E}_{\tau'|\tau}[\partial \mathcal{M}^r(s')/\partial b'] + \Delta'_{\mathcal{M}} f(\tau'|\tau) \right)$ in condition (30), one obtains

$$\frac{\partial \mathcal{M}^r(s)}{\partial b} = u_g(g) \frac{\partial \mathcal{G}^r(s)}{\partial b} - \alpha \psi_\pi(\pi) \frac{\partial \Pi^r(s)}{\partial b} - \left(u_g(g) \frac{\partial \hat{\mathcal{G}}^r(\hat{s})}{\partial \pi} - \alpha \psi_\pi(\pi) \right) \frac{\frac{\partial \mathcal{B}^r(s)}{\partial b}}{\frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi}}.$$

[33] The derivations are similar to those in Cuadra and Sapriza (2008) and Niemann, Pichler, and Sorger (2013) who derive Euler equations for related models with political frictions or monetary-fiscal policy interactions (see Section 1 for details).

By using the conditions

$$\begin{aligned}
\frac{\partial \hat{\mathcal{G}}^r(\hat{s})}{\partial \pi} &= \lambda \pi^{-2} b + \Delta_q \frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi}, && (31)\\
\frac{\partial \mathcal{G}^r(s)}{\partial b} &= \lambda \pi^{-2} b \frac{\partial \Pi^r(s)}{\partial b} - \Delta_\lambda + \Delta_q \frac{\partial \mathcal{B}^r(s)}{\partial b}, && (32)
\end{aligned}$$

which are derived by differentiating the government budget constraint with respect to π and b, this condition can further be rewritten as

$$\begin{aligned}
\frac{\partial \mathcal{M}^r(s)}{\partial b} &= u_g(g)\left(\lambda \pi^{-2} b \frac{\partial \Pi^r(s)}{\partial b} - \Delta_\lambda + \Delta_q \frac{\partial \mathcal{B}^r(s)}{\partial b}\right) - \alpha \psi_\pi(\pi) \frac{\partial \Pi^r(s)}{\partial b} \\
&\quad - \left(u_g(g)\left(\lambda \pi^{-2} b + \Delta_q \frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi}\right) - \alpha \psi_\pi(\pi)\right) \frac{\frac{\partial \mathcal{B}^r(s)}{\partial b}}{\frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi}},
\end{aligned}$$

or

$$\frac{\partial \mathcal{M}^r(s)}{\partial b} = -u_g(g)\Delta_\lambda + \Delta_\alpha \left(\frac{\partial \Pi^r(s)}{\partial b} - \frac{\frac{\partial \mathcal{B}^r(s)}{\partial b}}{\frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi}}\right). \qquad (33)$$

As in Section 3, I use the definitions

$$\begin{aligned}
\Delta_\alpha &\equiv u_g(g)\lambda \pi^{-2} b - \alpha \psi_\pi(\pi), \\
\Delta_\lambda &\equiv \lambda \pi^{-1} + 1 - \lambda, \\
\Delta_q &\equiv \lambda q_N(b', \tau) + (1-\lambda) q_R(b', \tau) + \left(\lambda \frac{\partial q_N(b', \tau)}{\partial b'} + (1-\lambda)\frac{\partial q_R(b', \tau)}{\partial b'}\right) b'.
\end{aligned}$$

By eliminating $\partial \hat{\mathcal{G}}(\hat{s})/\partial \pi$ in (29) via (31), one obtains

$$\Delta_\alpha + u_g(g)\Delta_q \frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi} + \beta\left(\mathbb{E}_{\tau'|\tau,\tau' \geq \hat{\tau}(b')}\left[\frac{\partial \mathcal{M}^r(s')}{\partial b'}\right] + \Delta'_{\mathcal{M}} \frac{\partial \hat{\tau}(b')}{\partial b'} f(\hat{\tau}(b')|\tau)\right) \frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi} = 0. \qquad (34)$$

After updating (33) one period ahead and using it to eliminate $\partial \mathcal{M}^r(s')/\partial b'$ in (34), one arrives at

$$\begin{aligned}
0 &= u_g(g)\Delta_q \frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi} + \Delta_\alpha \\
&\quad -\beta\left(\mathbb{E}_{\tau'|\tau,\tau' \geq \hat{\tau}(b')}\left[u_g(g')\Delta'_\lambda - \Delta'_\alpha\left(\frac{\partial \Pi^r(s')}{\partial b'} - \frac{\frac{\partial \mathcal{B}^r(s')}{\partial b'}}{\frac{\partial \hat{\mathcal{B}}^r(\hat{s}')}{\partial \pi'}}\right)\right] - \Delta'_{\mathcal{M}} \frac{\partial \hat{\tau}(b')}{\partial b'} f(\hat{\tau}(b')|\tau)\right) \frac{\partial \hat{\mathcal{B}}^r(\hat{s})}{\partial \pi},
\end{aligned}$$

which is the Euler equation for the central bank presented in Section 3.

A.1.2 Euler Equation for the Fiscal Authority

The first-order condition for the fiscal policy problem is given by

$$0=\theta u_g(g)\Delta_q+\beta\left(\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\begin{bmatrix}\mu\frac{\partial\mathcal{F}^r(s')}{\partial b'}\\+(1-\mu)\frac{\partial\mathcal{F}^{*r}(s')}{\partial b'}\end{bmatrix}+(1-\mu)\Delta'_{\mathcal{F}^*}\frac{\partial\hat{\tau}(b')}{\partial b'}f(\hat{\tau}(b')|\tau)\right),\quad(35)$$

with

$$\Delta_{\mathcal{F}^*}=\mathcal{F}^{*d}(\hat{\tau}(b))-\mathcal{F}^{*r}(b,\hat{\tau}(b)).$$

The value $\mathcal{F}^r(s)$ satisfies

$$\mathcal{F}^r(s)=\theta u(\mathcal{G}^r(s))-\psi(\Pi(s))+\beta\mathbb{E}_{\tau'|\tau'}\begin{bmatrix}\mu\mathcal{F}(\mathcal{B}^r(s),\tau')\\+(1-\mu)\mathcal{F}^*(\mathcal{B}^r(s),\tau')\end{bmatrix}.$$

Differentiating $\mathcal{F}^r(s)$ with respect to b yields

$$\begin{aligned}\frac{\partial\mathcal{F}^r(s)}{\partial b}&=\theta u_g(g)\frac{\partial\mathcal{G}^r(s)}{\partial b}-\psi_\pi(\pi)\frac{\partial\Pi^r(s)}{\partial b}\\&\quad+\beta\left(\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\begin{bmatrix}\mu\frac{\partial\mathcal{F}^r(s')}{\partial b'}\\+(1-\mu)\frac{\partial\mathcal{F}^{*r}(s')}{\partial b'}\end{bmatrix}+(1-\mu)\Delta'_{\mathcal{F}^*}\frac{\partial\hat{\tau}(b')}{\partial b'}f(\hat{\tau}(b')|\tau)\right)\frac{\partial\mathcal{B}^r(s)}{\partial b}.\end{aligned}\quad(36)$$

Using the first-order condition (35), (36) can be written as

$$\frac{\partial\mathcal{F}^r(s)}{\partial b}=\theta u_g(g)\frac{\partial\mathcal{G}^r(s)}{\partial b}-\psi_\pi(\pi)\frac{\partial\Pi^r(s)}{\partial b}-\theta u_g(g)\Delta_q\frac{\partial\mathcal{B}^r(s)}{\partial b}.$$

When combined with (32), this expression can be written as

$$\begin{aligned}\frac{\partial\mathcal{F}^r(s)}{\partial b}&=\theta u_g(g)\left(\lambda\pi^{-2}b\frac{\partial\Pi^r(s)}{\partial b}-\Delta_\lambda+\Delta_q\frac{\partial\mathcal{B}^r(s)}{\partial b}\right)\\&\quad-\psi_\pi(\pi)\frac{\partial\Pi^r(s)}{\partial b}-\theta u_g(g)\Delta_q\frac{\partial\mathcal{B}^r(s)}{\partial b},\end{aligned}$$

which reduces to

$$\frac{\partial\mathcal{F}^r(s)}{\partial b}=\Delta_\theta\frac{\partial\Pi^r(s)}{\partial b}-\theta u_g(g)\Delta_\lambda,\quad(37)$$

when using the definition $\Delta_\theta \equiv \theta u_g(g)\lambda\pi^{-2}b - \psi_\pi(\pi)$ from Section 3. For the party currently not in office, the value $\mathcal{F}^{*r}(s)$ satisfies

$$\mathcal{F}^{*r}(s) = u(\mathcal{G}^r(s)) - \psi(\Pi^r(s)) + \beta\mathbb{E}_{\tau'|\tau}\begin{bmatrix} \mu\mathcal{F}^*(\mathcal{B}^r(s),\tau') \\ +(1-\mu)\mathcal{F}(\mathcal{B}^r(s),\tau') \end{bmatrix}.$$

Differentiating $\mathcal{F}^{*r}(s)$ with respect to b yields

$$\begin{aligned}\frac{\partial\mathcal{F}^{*r}(s)}{\partial b} &= u_g(g)\frac{\partial\mathcal{G}^r(s)}{\partial b} - \psi_\pi(\pi)\frac{\partial\Pi^r(s)}{\partial b} \\ &\quad +\beta\left(\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\begin{bmatrix}\mu\frac{\partial\mathcal{F}^{*r}(s')}{\partial b'} \\ +(1-\mu)\frac{\partial\mathcal{F}^r(s')}{\partial b'}\end{bmatrix} + \mu\Delta'_{\mathcal{F}^*}\right)\frac{\partial\mathcal{B}^r(s)}{\partial b}.\end{aligned} \tag{38}$$

By rewriting the first-order condition (35), one obtains the expression

$$\begin{aligned}&\beta\left(\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\frac{\partial\mathcal{F}^{*r}(s')}{\partial b'}\right] + \Delta'_{\mathcal{F}^*}\frac{\partial\hat{\tau}(b')}{\partial b'}f(\hat{\tau}(b')|\tau)\right) \\ &= \frac{1}{1-\mu}\left[-\theta u_g(g)\Delta_q - \beta\mu\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\frac{\partial\mathcal{F}^r(s')}{\partial b'}\right]\right].\end{aligned} \tag{39}$$

Inserting (39) into (38) yields

$$\begin{aligned}\frac{\partial\mathcal{F}^{*r}(s)}{\partial b} &= u_g(g)\frac{\partial\mathcal{G}^r(s)}{\partial b} - \psi_\pi(\pi)\frac{\partial\Pi^r(s)}{\partial b} \\ &\quad + \begin{bmatrix}\frac{\mu}{1-\mu}\left[-\theta u_g(g)\Delta_q - \beta\mu\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\frac{\partial\mathcal{F}^{rr}(s')}{\partial b'}\right]\right] \\ +(1-\mu)\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\frac{\partial\mathcal{F}^r(s')}{\partial b'}\right]\end{bmatrix}\frac{\partial\mathcal{B}^r(s)}{\partial b}\end{aligned}$$

which reduces to

$$\begin{aligned}\frac{\partial\mathcal{F}^{*r}(s)}{\partial b} &= u_g(g)\frac{\partial\mathcal{G}^r(s)}{\partial b} - \psi_\pi(\pi)\frac{\partial\Pi^r(s)}{\partial b} - \mu\frac{\theta u_g(g)}{1-\mu}\Delta_q\frac{\partial\mathcal{B}^r(s)}{\partial b} \\ &\quad +\beta\frac{1-2\mu}{1-\mu}\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\frac{\partial\mathcal{F}^r(s')}{\partial b'}\right]\frac{\partial\mathcal{B}^r(s)}{\partial b}.\end{aligned}$$

With (37), this expression can further be written as

$$\begin{aligned}\frac{\partial\mathcal{F}^{*r}(s)}{\partial b} &= u_g(g)\frac{\partial\mathcal{G}^r(s)}{\partial b} - \psi_\pi(\pi)\frac{\partial\Pi^r(s)}{\partial b} - \mu\frac{\theta u_g(g)}{1-\mu}\Delta_q\frac{\partial\mathcal{B}^r(s)}{\partial b} \\ &\quad +\beta\frac{1-2\mu}{1-\mu}\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\Delta'_\theta\frac{\partial\Pi^r(s')}{\partial b'} - \theta u_g(g')\Delta'_\lambda\right]\frac{\partial\mathcal{B}^r(s)}{\partial b}.\end{aligned} \tag{40}$$

Updating (37) and (40) one period ahead and inserting the resulting expressions into the first-order condition (35) leads to

$$\begin{aligned}
0 &= \theta u_g(g)\Delta_q + \beta\mu\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\Delta'_\theta\frac{\partial\Pi^r(s')}{\partial b'} - \theta u_g(g')\Delta'_\lambda\right] + \beta(1-\mu)\Delta_{\mathcal{F}^*}\frac{\partial\hat{\tau}(b')}{\partial b'}f(\hat{\tau}(b')|\tau) \\
&+\beta(1-\mu)\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\begin{array}{c} u_g(g')\frac{\partial\mathcal{G}^r(s')}{\partial b'} - \psi_\pi(\pi')\frac{\partial\Pi^r(s')}{\partial b'} - \mu\frac{\theta u_g(g')}{1-\mu}\Delta'_q\frac{\partial\mathcal{B}^r(s')}{\partial b'} \\ +\beta\frac{1-2\mu}{1-\mu}\mathbb{E}_{\tau''|\tau',\tau''\geq\hat{\tau}(b'')}\left[\Delta''_\theta\frac{\partial\Pi^r(s'')}{\partial b''} - \theta u_g(g'')\Delta''_\lambda\right]\frac{\partial\mathcal{B}^r(s')}{\partial b'}\end{array}\right].
\end{aligned}$$

After rearranging this condition a little bit, one finally arrives at the Euler equation for the fiscal authority:

$$\begin{aligned}
0 &= \theta u_g(g)\Delta_q \\
&-\mu\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\theta u_g(g')\Delta'_\lambda - \Delta'_\theta\frac{\partial\Pi^r(s')}{\partial b'}\right] \\
&+(1-\mu)\beta\left(\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[u_g(g')\frac{\partial\mathcal{G}^r(s')}{\partial b'} - \psi_\pi(\pi')\frac{\partial\Pi^r(s')}{\partial b'}\right] + \Delta'_{\mathcal{F}^*}\frac{\partial\hat{\tau}(b')}{\partial b'}f(\hat{\tau}(b')|\tau)\right) \\
&-\mu\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\theta u_g(g')\Delta'_q\frac{\partial\mathcal{B}^r(s')}{\partial b'}\right] \\
&+(2\mu-1)\beta\mathbb{E}_{\tau'|\tau,\tau'\geq\hat{\tau}(b')}\left[\beta\mathbb{E}_{\tau''|\tau',\tau''\geq\hat{\tau}(b'')}\left[\theta u_g(g'')\Delta''_\lambda - \Delta''_\theta\frac{\partial\Pi^r(s'')}{\partial b''}\right]\frac{\partial\mathcal{B}^r(s')}{\partial b'}\right].
\end{aligned}$$

A.2 Numerical Solution

The numerical solution algorithm extends the algorithm proposed by Hatchondo, Martinez, and Sapriza (2010) for a standard sovereign default model as in Arellano (2008) to a setting with two optimizing authorities. The algorithm computes the policy and value functions $\mathcal{X}^r(b,\tau)$, $\mathcal{X}\in\{\mathcal{F},\mathcal{F}^*,\mathcal{M},\mathcal{B},\mathcal{G},\Pi\}$, and $\mathcal{X}^d(\tau)$, $\mathcal{X}\in\{\mathcal{F},\mathcal{F}^*,\mathcal{M},\mathcal{G},\Pi\}$. As in Hatchondo, Martinez, and Sapriza (2010), I approximate these functions on discrete grids for debt and tax revenues, using cubic spline interpolation to allow for off-grid values of b and τ. To reduce the computational burden, I exploit the additive separability of the period objective function and reformulate the within-period interaction between the fiscal authority and the central bank without changing equilibrium outcomes.

A.2.1 Reformulated Model

Conditional on repayment, the problem of the central bank can also be written as

$$\mathcal{M}^r(b,\tau) = \max_{\pi\geq\pi_{min}}\left\{-\alpha\psi(\pi) + \tilde{\mathcal{M}}^r(a,\tau)\right\} \quad s.t.\ \ a = \left(\lambda\pi^{-1}+1-\lambda\right)b.$$

The variable a combines the inflation rate π and the debt position b to a single intra-period state variable.[34] In equilibrium, the value functions for the repayment case then satisfy

$$\begin{aligned}\mathcal{M}^r(b,\tau) &= -\alpha\psi(\Pi^r(b,\tau)) + \tilde{\mathcal{M}}^r(\mathcal{A}^r(b,\tau),\tau),\\ \mathcal{F}^r(b,\tau) &= -\psi(\Pi^r(b,\tau)) + \tilde{\mathcal{F}}^r(\mathcal{A}^r(b,\tau),\tau),\\ \mathcal{F}^{*r}(b,\tau) &= -\psi(\Pi^r(b,\tau)) + \tilde{\mathcal{F}}^{*r}(\mathcal{A}^r(b,\tau),\tau),\end{aligned}$$

with

$$\mathcal{A}^r(b,\tau) = \left(\lambda\Pi^r(b,\tau)^{-1} + 1 - \lambda\right)b.$$

The fiscal policy problem now is given by

$$\tilde{\mathcal{F}}^r(a,\tau) = \max_{b'}\left\{\begin{array}{c}\theta u(\tau - a + [\lambda q_N(b',\tau) + (1-\lambda)q_R(b',\tau)]b') \\ +\beta\mathbb{E}_{\tau'|\tau}\left[\begin{array}{c}\mu\mathcal{F}(b',\tau') \\ +(1-\mu)\mathcal{F}^*(b',\tau')\end{array}\right]\end{array}\right\}.$$

The intra-period continuation values for the central bank and the political party not in office satisfy

$$\tilde{\mathcal{M}}^r(a,\tau) = \left\{u(\tilde{\mathcal{G}}^r(a,\tau)) + \beta\mathbb{E}_{\tau'|\tau}\left[\mathcal{M}(\tilde{\mathcal{B}}^r(a,\tau),\tau')\right]\right\},$$

and

$$\tilde{\mathcal{F}}^{*r}(a,\tau) = \left\{u(\tilde{\mathcal{G}}^r(a,\tau)) + \beta\mathbb{E}_{\tau'|\tau}\left[\begin{array}{c}\mu\mathcal{F}^*(\tilde{\mathcal{B}}^r(a,\tau),\tau') \\ +(1-\mu)\mathcal{F}(\tilde{\mathcal{B}}^r(a,\tau),\tau')\end{array}\right]\right\}.$$

In the default case, the central bank solves

$$\mathcal{M}^d(\tau) = \max_{\pi\geq\pi_{min}}\left\{-\alpha\psi(\pi) + \tilde{\mathcal{M}}^d(\tau)\right\}.$$

It is obvious that the central bank is not able to affect the behavior of the fiscal authority in the default case since the inflation rate does not have an impact on the government budget constraint. Regardless of the state τ, the inflation policy then satisfies $\alpha\psi_\pi(\Pi^d(\tau)) = 0$. Government spending is given as

[34] For the case of i.i.d. tax revenues, a could also include τ. For persistent tax revenues however, the current value τ will be needed to form expectations about τ'.

$\mathcal{G}^d(\tau) = \tau - \phi(\tau)$. The value functions satisfy

$$\mathcal{M}^d(\tau) = \left\{ \begin{array}{c} u(\mathcal{G}^d(\tau)) - \alpha\psi(\Pi^d(\tau)) \\ +\beta\mathbb{E}_{\tau'|\tau}\left[\delta\mathcal{M}(0,\tau') + (1-\delta)\mathcal{M}^d(\tau')\right] \end{array} \right\},$$

$$\mathcal{F}^d(\tau) = \left\{ \begin{array}{c} \theta u(\mathcal{G}^d(\tau)) - \psi(\Pi^d(\tau)) \\ +\delta\beta\mathbb{E}_{\tau'|\tau}\left[\begin{array}{c} \mu\mathcal{F}(0,\tau') \\ (1-\mu)\mathcal{F}^*(0,\tau') \end{array} \right] \\ +(1-\delta)\beta\mathbb{E}_{\tau'|\tau}\left[\begin{array}{c} \mu\mathcal{F}^d(\tau') \\ (1-\mu)\mathcal{F}^{*d}(\tau') \end{array} \right] \end{array} \right\},$$

and

$$\mathcal{F}^{*d}(\tau) = \left\{ \begin{array}{c} u(\mathcal{G}^d(\tau)) - \psi(\Pi^d(\tau)) \\ +\delta\beta\mathbb{E}_{\tau'|\tau}\left[\begin{array}{c} \mu\mathcal{F}^*(0,\tau') \\ (1-\mu)\mathcal{F}(0,\tau') \end{array} \right] \\ +(1-\delta)\beta\mathbb{E}_{\tau'|\tau}\left[\begin{array}{c} \mu\mathcal{F}^{*d}(\tau') \\ (1-\mu)\mathcal{F}^d(\tau') \end{array} \right] \end{array} \right\}.$$

A.2.2 Solution Algorithm

The numerical solution algorithm consists of the following steps:

1. Construct discrete grids for debt $[\underline{b}, \overline{b}]$, tax revenues $[\underline{\tau}, \overline{\tau}]$ and the intra-period state variable $[\underline{a}, \overline{a}]$.

2. Choose initial values for the policy and value functions $\mathcal{X}^r_{start}(b,\tau)$ and $\mathcal{X}^d_{start}(\tau)$, $\mathcal{X} \in \{\mathcal{F}, \mathcal{F}^*, \mathcal{M}, \mathcal{G}, \Pi\}$, at all grid points $(b,\tau) \in [\underline{b}, \overline{b}] \times [\underline{\tau}, \overline{\tau}]$.

3. Set $\mathcal{X}^j_{next} = \mathcal{X}^j_{start}$, $j \in \{r, d\}$ and fix an error tolerance ε.

   (a) For each grid point combination $(a,\tau) \in [\underline{a}, \overline{a}] \times [\underline{\tau}, \overline{\tau}]$, compute the policies $\tilde{\mathcal{B}}^r(a,\tau)$ and $\tilde{\mathcal{G}}^r(a,\tau)$ that solve the fiscal policy problem, and calculate the associated values $\tilde{\mathcal{X}}^r(a,\tau)$, $\mathcal{X} \in \{\mathcal{F}, \mathcal{F}^*, \mathcal{M}\}$.

   (b) For each grid point combination $(b,\tau) \in [\underline{b}, \overline{b}] \times [\underline{\tau}, \overline{\tau}]$, compute the inflation rate $\Pi^r_{new}(b,\tau)$ that solves the monetary policy problem, and calculate the associated fiscal policies and values $\mathcal{X}^r_{new}(b,\tau)$, $\mathcal{X} \in \{\mathcal{F}, \mathcal{F}^*, \mathcal{M}, \mathcal{B}, \mathcal{G}\}$.

(c) For each revenue value $\tau \in [\underline{\tau}, \overline{\tau}]$, compute the policies $\mathcal{G}^d_{new}(\tau)$ and $\Pi^d_{new}(\tau)$ that satisfy $\alpha\psi_\pi(\Pi^d_{new}(\tau)) = 0$ and $\mathcal{G}^d_{new}(\tau) = \tau - \phi(\tau)$, as well as the associated values $\mathcal{X}^d_{new}(\tau)$, $\mathcal{X} \in \{\mathcal{F}, \mathcal{F}^*, \mathcal{M}\}$.

(d) If $|\mathcal{X}^r_{new}(b,\tau) - \mathcal{X}^r_{next}(b,\tau)| < \varepsilon$ and $\left|\mathcal{X}^d_{new}(\tau) - \mathcal{X}^d_{next}(\tau)\right| < \varepsilon$, $\mathcal{X} \in \{\mathcal{F}, \mathcal{F}^*, \mathcal{M}, \mathcal{G}, \Pi\}$, for all grid point combinations, go to step 4, else set $\mathcal{X}^j_{next} = \mathcal{X}^j_{new}$, $j \in \{r,d\}$ and repeat step 3.

4. Take $\mathcal{X}^j_{new}(\cdot)$, $j \in \{r,d\}$, as approximations of the respective equilibrium objects in the infinite-horizon economy.

I use discrete grids with equidistant grid points. Since the grid for the intra-period state variable a is directly related to the debt grid, I set $[\underline{a}, \overline{a}] = [\underline{b}, \overline{b}]$. The asymmetric default costs lead to a kink at $\tau = \tilde{\tau}$ in $\mathcal{X}^d(\tau)$, $\mathcal{X} \in \{\mathcal{F}, \mathcal{F}^*, \mathcal{M}, \mathcal{G}, \Pi\}$. To address this discontinuity in an approriate way, I partition the τ-grid for the default case into two parts as in Hatchondo, Martinez, and Sapriza (2010). I choose an error tolerance of $\varepsilon = 10^{-5}$.

Following Hatchondo, Martinez, and Sapriza (2010), I solve for the infinite-horizon limit of a finite-horizon model version. I thus first compute the value and policy functions for the final period problem where no borrowing decision is made and use the resulting objects as initial values $\mathcal{X}^j_{start}$, $j \in \{r,d\}$, for step 2. Note that in the final period, the central bank can effectively choose government spending g via the government budget constraint: $g = \tau - \left(\lambda\pi^{-1} + 1 - \lambda\right)b$.

For step 3a, the debt policy $\tilde{\mathcal{B}}^r(a,\tau)$ is computed via a global non-linear optimizer. First, the algorithm performs a grid search over a pre-defined grid for b'. Then, the solution to this grid search is used as an initial guess for the Nelder-Mead algorithm. The optimization step delivers values for $\tilde{\mathcal{M}}^r(\cdot)$, $\tilde{\mathcal{F}}^r(\cdot)$ and $\tilde{\mathcal{F}}^{*r}(\cdot)$ that are associated with the optimal debt and government spending response functions $\tilde{\mathcal{G}}^r(\cdot)$ and $\tilde{\mathcal{B}}^r(\cdot)$.

Given the response functions and continuation values obtained in step 3a, step 3b computes the inflation policy $\Pi^r_{new}(b,\tau)$ that solves the central bank problem for each grid point combination (b,τ) $\in [\underline{b}, \overline{b}] \times [\underline{\tau}, \overline{\tau}]$. Using the calculated inflation policy $\Pi^r_{new}(b,\tau)$, the equilibrium fiscal policies and continuation values are computed by evaluating the functions $\tilde{\mathcal{X}}^r(a,\tau)$, $\mathcal{X} \in \{\mathcal{F}, \mathcal{F}^*, \mathcal{M}, \mathcal{B}, \mathcal{G}\}$, at $a = \left(\lambda\Pi^r_{new}(b,\tau)^{-1} + 1 - \lambda\right)b$.

To accurately compute expected values for the optimization in step 3a, it is important to account for the discontinuity generated by the discrete default decision. To illustrate this, take a look at the continuation value for the central bank in the repayment case:

$$\mathbb{E}_{\tau'|\tau}\left[\mathcal{M}_{next}(b',\tau')\right] = \int_0^{\hat{\tau}(b')} \mathcal{M}^d_{next}(\tau')f(\tau'|\tau)d\tau' + \int_{\hat{\tau}(b')}^{\infty} \mathcal{M}^r_{next}(b',\tau')f_\tau(\tau'|\tau)d\tau',$$

where $f(\cdot)$ is the conditional probability density function for future tax revenues τ'. One can characterize the default decision of the fiscal authority via a threshold $\hat{\tau}(b)$ for tax revenues that satisfies $\Delta_{\mathcal{F}}(b,\hat{\tau}(b)) \equiv \mathcal{F}^r(b,\hat{\tau}(b)) - \mathcal{F}^d(\hat{\tau}(b)) = 0$. Given the debt position b, $\hat{\tau}(b)$ is the lowest τ-value for which the fiscal authority prefers to repay its debt. For $\tau < \hat{\tau}(b')$, the fiscal authority finds it optimal to default. I compute the default threshold $\hat{\tau}(b)$ via bisection method. Following Hatchondo, Martinez, and Sapriza (2010), I use Gauss-Legendre quadrature nodes and weights to approximate the integrals above.