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Abstract

Should a government have more than one fiscal rule constraining fiscal aggregates? If so, why? In this paper, we present a dynamic general equilibrium model of a small open economy featuring an incumbent government to assess how and why implementing a budget balance rule and a debt anchor rule is non-redundant and welfare-improving. Our findings suggest that the implementation of a combination of fiscal rules is optimally preferred over a single rule, as each rule has a different effect on credibility and fiscal behaviour. While the debt anchor rule prevents the propagation of the negative effects of imperfect fiscal credibility, the operational rule reduces amplification by avoiding overindebtedness and minimizing the welfare-detrimental effects arising from a deficit-biased government.

Keywords: Fiscal Rules, Credibility, Deficit Bias, Balanced Budget Rule, Debt Anchor Rule, Fiscal Policy, Welfare

JEL Codes: E61, E62, H60, H63, F41

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1 Introduction

Public debt has grown remarkably over the years (Figure 1, Panel A). This has been the consequence of many forces. In part, it has been the result of shocks, such as the COVID-19 pandemic, that required the countercyclical response by governments around the world. In some countries it has also been the result of political pressures to increase public spending and meet social demands (Alesina & Passalacqua, 2016). This has also been facilitated by long periods of loose financial conditions and very low interest rates since the Global Financial Crisis.

The large increase in public debt raises the issue of sustainability, a concern that gains importance as the long period of low interest rates comes to an end in developed countries. However, economic institutions have also responded. Along with the increase in debt, there has been an increase in the adoption of fiscal rules (Figure 1, Panel B). Moreover, there has been an increase in the number of fiscal rules that a given country has. Apart from the supranational fiscal rules of monetary unions, most countries have at least two rules constraining fiscal budgetary aggregates, and the most common combination of them constrains debt, budget balance, and expenditure, as shown in Figure 1, Panel C.

In fact, the International Monetary Fund (IMF) has been a proponent of a *two-pillar approach* to fiscal rules. According to Lledo et al. (2018) and Andrle et al. (2015), countries should take a modern approach to fiscal rules that makes use of a debt anchor and an operational fiscal rule. The debt rule intends to set a medium-term objective which speaks to fiscal sustainability, while the operational rule provides practical guidance. However, since constraining the fiscal balance implicitly sets a limit on debt growth, a balanced budget rule and a debt rule would become redundant. Nonetheless, evidence shows that the number of countries with more than one rule is large and steadily growing, and the policy recommendation (for bodies such as the IMF) is that countries should implement a combination of rules.

But should countries use a combination of fiscal rules? And if so, why? This paper develops a theoretical framework to answer this question. In a setting where fluctuations in output are caused by business cycle shocks and the government has a tendency to overspend in the short run, implementing a combination of fiscal rules can improve overall welfare. These rules constrain government spending while allowing for countercyclical responses to certain shocks without suffering significant credibility losses, ultimately resulting in better economic outcomes. This provides theoretical support for the policy recommendation that has already been documented and observed in practice.

We develop a general equilibrium model of a small open economy and compare the economy's outcomes when there are no fiscal rules in place, as well as when there is a debt rule, a balanced budget rule, and a combination of the two. According to Eyraud et al. (2018) and Lledo et al. (2018), countries should adopt a combination of fiscal rules such that each rule targets a different fiscal objective. Since the budget and debt should be mechanically interconnected (except for reasons such as creative accounting, see De Castro-

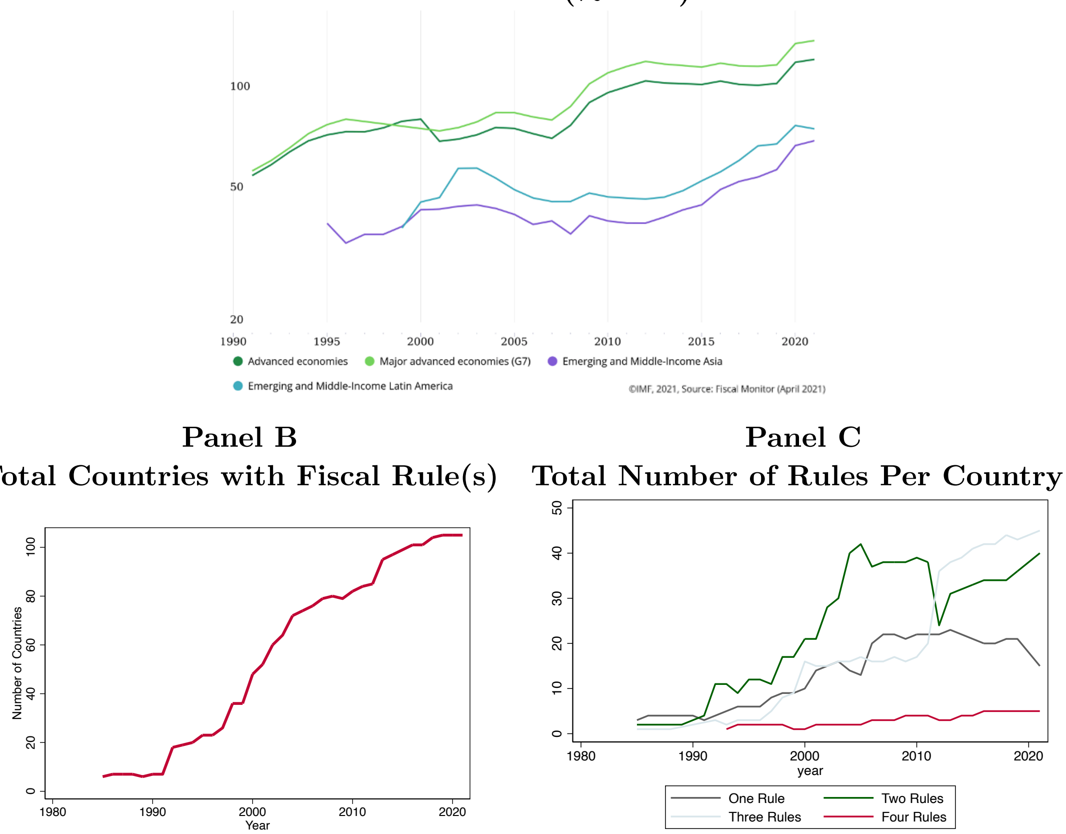
Valderrama (2021)), there is no discernible reason why there should be one rule for each of those budgetary aggregates. We provide a plausible justification. In our model, there will be two fiscal rules aimed at tackling two distortions in the economy that capture common features that we observe in fiscal policy.

Figure 1: Public Debt and Fiscal Rules Over Time

Panel A
Evolution of Public Debt (%GDP) Over Time

Panel B
Total Countries with Fiscal Rule(s)

Panel C
Total Number of Rules Per Country



Source: International Monetary Fund - Fiscal Rules Data Base

First, fiscal credibility, understood as a government's perceived ability and willingness to repay its debt, is generally not perfect, even if the government has a good track record. In the model, the further away the debt-to-GDP ratio is from its target, even if it is due to an optimal response to exogenous shocks, the lower is credibility.[1] Furthermore, given the political nature of the government, it does not internalise that the interest rate it faces partially depends on its borrowing decision, as in Arellano (2008). To counteract the effects of this nearsightedness and the distortion that imperfect credibility has on financing costs and the economy, we introduce a debt target rule. Following a shock that the government will respond to by changing its debt, the rule will consist of making an announcement of a medium-term debt target and committing to the debt path of a government that internalises

[1]We define fiscal credibility similar to de Mendonça & Machado (2013).

the price effect of its debt decision (thereafter a prudent government).

Second, it is also common that current government officials tend to overspend, perhaps for political reasons such as trying to stay in power. In other words, the incumbent exhibits deficit bias that results in welfare-detrimental fiscal aggregates, as in Amador et al. (2006) and Halac & Yared (2014, 2018). The operational rule will constrain government spending in a given period so that the present-biased government, which is time-inconsistent and unconstrained, leads the country to be over-indebted.

Our findings can be summarised in four main points. Firstly, although both fiscal rules, the debt target rule and balanced budget rule (operational rule), improve welfare individually, the combination of both rules is better than each rule separately. This is the case because each rule operates through different mechanisms and solves different problems.

On the one hand, a balanced budget rule sets a limit on the fiscal balance to ensure that, even in the absence of output shocks over the business cycle, the incumbent does not spend more than a time-consistent government. This rule reduces the negative consequences of a deficit-biased government running an over-indebted country, making it easier for the economy to operate and respond to shocks. On the other hand, the debt target rule entails setting a prudent medium-term debt-to-GDP ratio target and committing to a debt path that leads to it optimally. After a negative output shock, for example, the rule would prompt the government to announce a debt level that it will seek to achieve some periods ahead. If such a target is significantly below the current debt level, investors will judge the target as too optimistic, and the government will lose credibility. However, if the government does stick to the prudent path that will drive debt to the medium-debt target, the credibility gains will be substantial. Sticking to the path contributes to minimising the propagation of shocks and improving current and expected financing costs, given that the announced path is a key determinant of the government's credibility stock. Commitment will then offset or moderate the potential credibility losses experienced when investors only judged the government's ability to repay debt looking at its current debt level. Of course, new shocks can materialise after the announcement, forcing the government to deviate from the promised path. Nevertheless, our simulations show that the prudent behaviour induced by this rule does help to maintain a higher credibility stock on average, anchor expectations, and ultimately works as a precautionary mechanism that creates larger fiscal space to respond better to future shocks.

Secondly, the welfare gains and economic implications of each rule and their combination are asymmetric depending on the direction of the output shock and the magnitude of the deficit bias. Thirdly, because of these asymmetrical responses, neither of the two rules dominates the other, and only a combination of the two yields better welfare outcomes. Lastly, when credibility is variable and fluctuates as a result of shocks, the two fiscal rules will be welfare-improving but they will be insufficient to get back to the second-best scenario of a non-distorted economy with a political government, as it will take time to recover after the credibility losses that ensue from lasting deviations of debt from its medium and long-term targets.

Our results provide some theoretical support for the use of a combination of fiscal rules. However, it does not follow that solely implementing several fiscal rules will always be welfare-improving nor that rules may not be redundant or even conflicting. Considering the issue that each rule helps to solve and how they interact is key to the design and calibration of each fiscal rule. Building the bridge between goals, rules, and the mechanisms through which they operate is a challenge.

Our paper contributes to the literature on the benefits, costs, and flaws of implementing different constraints on government behaviour. Notable examples include Azzimonti et al. (2016), Alfaro & Kanczuk (2017), Amador et al. (2006), and Halac & Yared (2014). To our knowledge, the literature has not studied how and why a combination of fiscal rules can be beneficial for countries even though, as mentioned, a combination of fiscal rules is a common practice and policy recommendation. This paper aims at filling this gap by providing a theoretical model that explicitly lays out the problems that each rule tries to solve and allowing us to study the interaction of the rules, evaluate the mechanisms through which each may operate, and jointly consider their design and calibration.

This paper also provides a theoretical framework to support policy recommendations for combining fiscal rules such as the the IMF's *two-pillar approach* mentioned earlier and explained in Lledo et al. (2018) and Andrle et al. (2015). Interestingly, Andrle et al. (2015) study different reaction functions of fiscal instruments to attain certain budgetary aggregate targets, akin to Taylor rules, in which instruments change systematically to shocks and variables in the economy, and compare the variability of GDP, GDP growth, and debt-to-GDP ratios under different rules.[2] Our work can facilitate the understanding of how different rules and their combination can achieve such outcomes. Nonetheless, the rules in our study differ from those in Andrle et al. (2015) in that we do not impose reaction functions on fiscal aggregates that are to be always followed, but we use fiscal rules that are set as limits or bounds for budgetary aggregates that can be occasionally binding, and when they are not, the government is free to choose. The political process, as well as the diverse goals pursued by different governments, increases the likelihood of implementing limits rather than reaction functions in practice.

Finally, our paper also contributes to understanding how fiscal rules can affect credibility and expectations in a setting of governments that are deficit-biased. This relates to the literature on the need for and ability of fiscal rules to constrain and solve the time-inconsistent behaviour of incumbent governments, such as Alesina & Passalacqua (2016); Halac & Yared (2014, 2018); Azzimonti et al. (2016); Alfaro & Kanczuk (2017); Hatchondo et al. (2022a); and Hatchondo et al. (2022b). It also relates to the literature that brings in time-variable credibility in the conduction of macroeconomic stabilisation policies, as Argov et al. (2007) do for monetary policy.

The rest of the paper is organised as follows: Section 2 presents the model, lays out the

[2] Related papers comparing fiscal policy rules include Kumhof & Laxton (2009); Minea & Villieu (2009), for an empirical evaluation, see Landon & Smith (2017).

fiscal rules, and explains the benchmark economies to determine the rules' limits. Section 3 presents the behaviour of the economy when there are no fiscal rules, how this changes with each rule and their combination, and the intuition behind the welfare gains of establishing fiscal rules when the economy suffers shocks that cause output fluctuations and the government is persistently time-inconsistent. Finally, Section 4 concludes.

2 The Model Economy

The model is one of an open economy with two agents: households and the government. They both demand a homogeneous good that is produced both domestically and internationally. The domestic supply is modelled as an endowment, while the foreign supply depends on the issuance of public and private debt. It is worth noting that public and private debts are not traded in any local markets.

Households make their decisions based on a standard utility maximisation problem. The government's problem is more complicated due to two distinct frictions. First, the government faces pressure to spend, for example due to political reasons, which results in a deficit bias. This bias leads to overindebtedness in the long-run, demonstrating dynamic inconsistency. Second, the government's credibility is variable and imperfect, resulting in additional pressure on debt service when public debt deviates significantly from its target. This deviation may occur due to business cycle shocks or the government's deficit bias. As a result, these frictions cause the government to make socially sub-optimal decisions, thereby allowing for the possibility to establish fiscal rules as a means to increase welfare.

2.1 Production

The economy's stochastic endowment yields output,[3] Y_t, and evolves according to the following AR(1) process:

$$Y_t = \rho_Y Y_{t-1} + (1 - \rho_Y)\bar{Y} + \varepsilon_t^Y \tag{1}$$

where $\bar{Y}$ represents the steady-state local supply of the homogeneous good, ρ_Y denotes the persistence of the process, and, $\varepsilon_t^Y \sim N(0, \sigma_Y^2)$, is an exogenous shock.

It is worth noting that the local endowment is divided between the government and households according to a constant tax rate, τ, set by the government. Then, the first round effect of any output fluctuation is a proportional change in the income of the government and households. However, as both agents have access to international markets, they can issue or repay debt to change their available income in response to shocks.

[3] Throughout the document, the terms endowment, output, and GDP will be used interchangeably.

2.2 Households

There is a continuum of households indexed by $j \in (0,1)$. The representative household j derives utility from both its consumption and the government's expenditure on public goods and services. To generate current income, the household relies on two sources: an after-tax, exogenous share of the aggregate endowment and the foreign debt it issues to investors. The household utilises this income to purchase goods and services, as well as service its share of the outstanding private foreign debt. Its objective is to maximise the expected value of lifetime utility while adhering to the budget constraint by deciding how much debt to issue and how much to consume:

$$\max_{\{C_{j,t},B^{\star}_{j,t}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \, \frac{(C^{\sigma}_{j,t} G^{1-\sigma}_{j,t})^{1-\theta}}{1-\theta}$$

subject to

$$C_{j,t} + B^{\star}_{j,t-1}(1+i^{p\star}_{t-1}) \leqslant (1-\tau)Y_{j,t} + B^{\star}_{j,t}$$

where $C_{j,t}$ is private consumption, G_t is public expenditure, $(1-\tau)Y_{j,t}$ is the private exogenous after-tax income, $B^{\star}_{j,t}$ is the foreign debt of household j, and $i^{p\star}_t$ equilibrium's foreign interest rate on private debt. As each household receives a constant share of the aggregate endowment and faces the same market interest rate as the others, in equilibrium, households are identical with respect to their debt and consumption decisions. Notice that all households take the market interest rate as given. The equilibrium first-order conditions (FOC) for the household are given as follows:

$$\frac{\left[C^{\sigma}_t G^{(1-\sigma)}_t\right]^{(1-\theta)}}{C_t} = \beta \mathbb{E}_t \left\{ (1+i^{p\star}_t) \frac{\left[C^{\sigma}_{t+1} G^{(1-\sigma)}_{t+1}\right]^{(1-\theta)}}{C_{t+1}} \right\} \tag{2}$$

$$(1-\tau)Y_t + B^{\star}_t = C_t + B^{\star}_{t-1}(1+i^{p\star}_{t-1}) \tag{3}$$

Equation (2) determines households' optimal intertemporal consumption given its discount factor β and the equilibrium interest rate, and Equation (3) is the households' aggregate budget constraint.

2.3 Government

To finance its public spending and debt service, the government employs two revenue sources: a constant tax rate levied on the economy's local endowment and the issuance of public debt to foreign investors. The government aims to maximise aggregate household utility; it acts as a benevolent government but cannot act as a central planner because it faces two frictions. The first friction is a market one, characterised by variable and imperfect credibility. If foreign investors observe that the government's debt is increasing significantly beyond its target, they believe that the government is less likely to follow a path of fiscal balances that will reduce debt. As a result, foreign investors revise their expected debt level upward and demand a higher interest rate as compensation for holding riskier debt.

The second friction directly alters the government's decisions. Owing to its present bias, the government incurs time-inconsistent behaviour, which translates into higher public spending and overindebtedness. This results in sub-optimal allocations, as the government will eventually have to make significant adjustments to its spending to stabilise its debt, which will hinder household utility more than the temporary increase in utility during the over-spending periods. Alesina & Passalacqua (2016) argue that a government with both an incentive to increase households' utility and a present bias resembles an incumbent government rather than a central planner.

2.3.1 Government with deficit-bias

The government chooses its public expenditure and foreign debt levels to maximise the expected value of households' lifetime utility:

$$\max_{\{G_t, D_t^\star\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} {\phi_t}^t \, \frac{(C_t^\sigma G_t^{1-\sigma})^{1-\theta}}{1-\theta}$$

subject to its budget constraint:

$$G_t + D_{t-1}^\star(1 + i_{t-1}^{G\star}) \leqslant \tau Y_t + D_t^\star$$

where τY_t is the tax revenue collected from the economy's endowment and $D_t^\star$ is the foreign public debt with interest rate $i_t^{G\star}$. Note that the government discounts with a stochastic factor, $\phi_t \in (0, \beta]$. The discount factor evolves according to $\phi_t = \beta - \varepsilon_t^\phi : \varepsilon_t^\phi \sim \mathcal{N}_{0 \leq \varepsilon_t^\phi < \beta}(0, \sigma_\phi^2)$. The truncated distribution of the innovations to the discount factor implies that the government always values the future less than or equal to what the household does, but never more.

Moreover, because the mean of these innovations is zero and the discount factor has no persistence, agents always expect the government to discount the future as much as households do but are surprised when it does not. Thus, when the innovation is greater than zero the government becomes time-inconsistent, as it values the next period's utility less today than it has done in the previous period (before the innovation it discounted the corresponding period's utility with factor β). This means that the government's decision about $t+1$ in period $t-1$ would have been different than the decision it effectively makes once $\varepsilon_t^\phi \neq 0$. Therefore, this dynamic inconsistency yields sub-optimal spending decisions.

The discount factor shock helps us model a present-biased government: for political economy reasons, the government's spending tends to increase beyond what it should. This characteristic is consistent with Eslava (2011), where political factors play a significant role in the incumbent government's decision to run fiscal deficits. Specifically, incumbents are inclined to use public spending to promote their political preferences over other groups' choices. Therefore, any shock to ε_t^ϕ would result in a present bias, thus indicating that the government behaves like a political incumbent. This implies that even though the government is benevolent, as it is aiming to maximise household's utility, it does not behave as a central planner and suffers overindebtedness.

The government's first order conditions are given by:

$$\frac{\left[C_t^{\sigma}G_t^{(1-\sigma)}\right]^{(1-\theta)}}{G_t} = \phi_t \mathbb{E}_t \left\{ (1+i_t^{G\star}) \frac{\left[C_{t+1}^{\sigma}G_{t+1}^{(1-\sigma)}\right]^{(1-\theta)}}{G_{t+1}} \right\} \tag{4}$$

$$\tau Y_t + D_t^{\star} = G_t + D_{t-1}^{\star}(1+i_{t-1}^{G\star}) \tag{5}$$

Equation (4) shows how government optimally decides how to spend on public goods and services, given the debt interest rate and its variable discount factor, while (5) is the public budget constraint.

2.4 Closing the economy

Following Schmitt-Grohe & Uribe (2003), in order to close the economy's equilibrium, the interest rates are assumed to be elastic to the debt-to-GDP ratios.

First, the interest rate on households' foreign debt is determined by:

$$1 + i_t^{p\star} = (1+i_t^{G\star})e^{\eta(b_t^{\star}-\bar{b}^{\star})} \tag{6}$$

where $b_t^{\star} = \frac{B_t^{\star}}{Y_t}$ is the foreign private debt-to-GDP ratio (henceforth, all debts in lower case will denote that they have been divided by GDP), and $\bar{b}^{\star}$ is its steady state. Additionally, the interest rate on private debt is directly affected by the interest rate on public debt, capturing the fact that the private sector usually pays a premium over the public sector's financing costs. Nevertheless, if the private debt-to-GDP ratio is below its steady state level, their interest rate can be lower than that of the government but will still be affected by it.

Before reviewing the determinants of the public interest rate, it is necessary to understand how government credibility is determined. First, there is a penalty that investors include when assessing government credibility when the government engage in time-inconsistent behaviour. The size of the penalty is measured by the overindebtedness augmenting factor OAF_t.[4]

$$OAF_t = \max\left(\frac{d_t^{\star}}{d_{ND,t}^{\star}}, 1\right) \tag{7}$$

where $d_{ND,t}^{\star}$ is the debt-to-GDP ratio of the non-distorted government (i.e., without a deficit bias) given the same endowment level than the one of the actual government.[5] There-

[4] In reality, investors estimate this factor, since they cannot perfectly observe the size of the deficit bias. However, employing a linearised version of our model together with a Kalman Filter (or a Particles Filter to use it in its nonlinear version) could actually help in assessing a government's bias and the corresponding OAF.

[5] Note that the non-distorted debt level is consistent with a government that solves the same problem as

fore, whenever the actual government increases its debt due to the deficit bias, OAF_t will be greater than one. This factor will increase the debt-to-GDP ratio that investors consider to assess a government's credibility whenever the deficit bias translates into overindebtedness. On the contrary, when public debt does not differ from that of a non-biased or non-distorted government, OAF_t value will remain one.

That said, the credibility index in Equation (8) is based on the one proposed in de Mendonça & Machado (2013) but taking into account the fact that foreign investors will also be forward-looking and consider the OAF_t when calculating the government's credibility index today, $\lambda_t \in (0, 1]$:

$$\lambda_t = 1 - \left[\frac{d_t^\star - d_t^{tar}}{d^{Max} - d_t^{tar}} + \left(\frac{\mathbb{E}_t \left\{ \sum_{s=t}^{k} d_s^\star \right\}}{k} - d_t^{tar} \right) + (OAF_t - 1) \right] \tag{8}$$

where d^{Max} could be interpreted as the natural debt limit, d_t^{tar} is the government's announcement in t of the debt ratio target that it will set itself to achieve in period $k, k \geq t$. There are three factors that determine the credibility index: the current debt level compared to its target, credibility of the announcement, and credibility losses derived from political distortions.

The first term of the parenthesis in Equation (8) shows how close the current debt-to-GDP ratio is from its target, as defined by de Mendonça & Machado (2013). This term worsens credibility when the government's target is farther away from the current level than from the maximum debt level. In this sense, the denominator of this part of the index can be thought of as government's fiscal space, as in Bi (2012), Hürtgen (2020), and Méndez-Vizcaíno & Moreno-Arias (2021); hence, the index will fall the more the government uses up its fiscal space.

The second term measures the credibility of the announcement by comparing how distanced the expected debt path on average is from the announced target. The further the debt path projections are from the announced target, the worse the credibility. Therefore, this term summarises if the announcement is credible by considering the expectations on the size of the adjustments the government will need to approach its target.

Finally, the third term is the reputational punishment that a government with deficit bias experiences. When $OAF_t = 1$ (there is no increase in debt due to the deficit bias), the credibility index will only reflect the deviation of current debt and the expected path to get to the announced target.

Moreover, government's credibility is assumed to be a stock and not a flow, as shown by Equation (9). The equation also shows that, ν_t, moves when the credibility index, λ_t, changes. Nonetheless, the credibility stock is also bounded: $\nu_t \in (0, 1]$.

$$\nu_t = \rho_\nu \nu_{t-1} + (1 - \rho_\nu)\lambda_t \tag{9}$$

the one presented in the previous section but whose discount factor is constant and always equal to β.

Similar to the private interest rate, the public interest rate reacts to a debt-to-GDP ratio:

$$1 + i_t^{G\star} = \left(1 + \overline{RF}\right)^{\frac{1}{\nu_{t-1}}} e^{\eta\left(I_t^{d^\star} - \bar{d}\right)} \tag{10}$$

where $\overline{RF}$ is the steady state foreign risk-free interest rate and $I_t^{d^\star}$ is the foreign investors' relevant public debt-to-GDP ratio. In contrast to the equation of the private interest rate, this equation features two outlets through which credibility affects the interest rate. First, the credibility stock directly changes the country's average risk premium. When the credibility stock falls below one, the intercept of the supply curve of foreign funds moves upward and makes the public interest rate higher for all public debt-to-GDP ratios. This captures the fact that when rating agencies downgrade sovereign debt, sovereign yields tend to rise as shown in Cantor & Packer (1996) and Larraín et al. (1997).

Second, another key way in which credibility influences financing costs comes from the variable part of the public interest rate, as it is not responding to the actual foreign public debt-to-GDP ratio, but to what we call the investors' relevant ratio ($I_t^{d^\star}$).

$$I_t^{d^\star} \equiv \nu_{t-1} d_t^\star + (1 - \nu_{t-1}) d^{Max} \tag{11}$$

The indicator mentioned above is a weighted average between the current foreign debt-to-GDP ratio and the natural debt limit. The credibility stock determines how much weight investors assign to the current level of public debt versus a future unsustainable or 'high' debt scenario. In that sense, the indicator is partially forward-looking and reflects the idea that investors are also worried about future sustainability when pricing public debt.

On the one hand, a less credible government is one whose track record signals a more irresponsible behaviour, and thus, that it would be more likely follow an unsustainable fiscal debt path in the future. In this case, investors will believe that such a government is less prone to run the fiscal surpluses needed to bring the debt ratio back to its target and assign a higher weight to the possibility that it follows an unsustainable debt path towards the debt limit. On the other hand, perfect credibility means that foreign lenders price government's debt considering solely the current debt-to-GDP ratio. Since $d_t^\star < d^{Max}$, higher credibility always implies that investors' relevant ratio, and thus, the foreign interest rate is lower than when the credibility is less than 1.

2.4.1 Equilibrium

The *equilibrium* of this economy is given by prices $\{i_t^{G\star}, i_t^{P\star}\}_{t=1}^{T}$ and allocations $\{C_t, G_t, D_t^\star, B_t^\star\}_{t=1}^{\infty}$ such that

① Optimal decisions determining the behaviour of agents are satisfied:

i. Households' optimal decisions hold.

ii. Government's optimal decisions hold.

② All markets clear:
$Y_t + D_t^\star + B_t^\star = C_t + G_t + i_{t-1}^{G\star} D_{t-1}^\star + i_{t-1}^{P\star} B_{t-1}^\star$ in the goods market.

2.4.2 Social Welfare

From this point forward, we will define social welfare as the present value of households' lifetime utility at time zero:

$$\mathcal{W}_0 = \sum_{t=0}^{\infty} \beta^t \, \frac{(C_t^{\sigma} G_t^{1-\sigma})^{1-\theta}}{1-\theta}$$

2.5 Fiscal Rules

The economy described above faces two distortions that make the resulting equilibrium not a first-best. This opens the possibility for fiscal rules to act as devices to reduce the consequences of these distortions and improve welfare. Here, we introduce fiscal rules in the model so that we can later study their effects on the dynamics and welfare of the economy.

To fix ideas, we introduce fiscal rules as inequality constraints, as in Azzimonti et al. (2016), which are part of the government's problem. In this way, the concept of rule that we employ follows Davoodi et al. (2022), who define a fiscal rule as an institutional constraint on fiscal policy that imposes numerical limits to budgetary aggregates. This definition implies that a fiscal rule sets a perimeter within which fiscal aggregates can freely evolve according to the government's discretion. We use this idea of limits to debt or deficits for our rules as opposed to the idea of a reaction function in the spirit of a Taylor rule, in which a policy instrument, say government spending, reacts systematically to some variables in the economy.

The first distortion arises when the government increases its debt, for example, due to shocks, because it becomes less credible and faces a higher interest rate that is passed through to the rest of the economy and makes the allocation of resources inefficient. The first fiscal rule aims at anchoring expectations about the evolution of debt by announcing and following a commitment to a prudent debt path. This rule reduces credibility losses and their cost because it ensures the return of the economy to sustainable debt levels after an adverse shock and reduces the cost of borrowing.

The second distortion emerges because the government exhibits deficit bias, which leads to overindebtedness. The incumbent government tends to overspend in the short-run due to political pressures, as it is the case in Halac & Yared (2014) and Azzimonti et al. (2016). Ultimately, this behaviour is sub-optimal and time-inconsistent and its negative consequences may not be resolved by a forward-looking rule implemented in response to shocks such as the first rule, but by a short-run operational rule that limits the fiscal balance in every period.

The details of each rule are presented in the following sections.

2.5.1 Fiscal Rule 1: Debt target

This first rule can be thought of as the so-called debt anchor rule in the IMF's *two pillar approach*. It provides a medium-term anchor for debt and works through the announcement and subsequent commitment to a debt-to-GDP ratio target that will be achieved some periods ahead. The main objective of this rule is to reduce the government's financing costs by signalling a more prudent behaviour to foreign investors, thereby building a higher credibility stock. [6]

Following a shock, the implementation of the rule works first through the announcement in period t of a debt anchor, that is, a debt target to be reached k periods ahead, and second, by constraining public debt to be at most on a target path of a prudent government every period from $t+1$ though $t+k$. The debt target rule is defined through the following constraints:

$$d_t^{tar} = \overline{d_t^{PR,k}} \tag{12}$$

$$d_{t+i}^{\star} \leq \overline{d_t^{PR,i}} \quad \forall i \in \{0, ..., k\} \tag{13}$$

where inequality (12) states that at time t, a debt target is announced and it is equal to the *prudent* debt-to-GDP ratio level $\overline{d_t^{PR,k}}$ that should be achieved k periods ahead. Expression (13) sets a limit on the path of public debt-to-GDP ratios from t to $t+i$ $\forall i \in \{0, ..., k\}$. Below these levels, it is considered that the government is acting prudently.

To determine the path of prudent debt ratios, we construct a counterfactual model where the government is prudent and faces the same economic conditions as the actual government. From this economy, we extract the path of debt that a prudent government would choose optimally. There are two features that characterise a prudent government. First, following the seminal work on sovereign default in Arellano (2008), the prudent government internalises the fact that issuing debt has a direct impact on the interest rate that investors will demand in new debt contracts, that is, in its debt decision, it incorporates the price impact that it has on the risk premium that the country faces as part of its borrowing cost. Second, after an adverse shock that increases debt, the prudent government commits to lowering debt to the announced target and chooses the optimal path to get there, taking into account the cost that its borrowing causes to the economy and attempting to maximise credibility through the announcement. The idea is that the prudent government generates precautionary savings on both its net foreign assets and its credibility stock. This savings enable it to mitigate adverse income fluctuations and achieve its target quickly, thereby enhancing its ability to react to future shocks.

The problem of the prudent government is as the one presented in Section 2.3, although now subject to (10) in order to take into account that the investors' relevant debt-to-GDP

[6] We label as a prudent government one that wants to respond to shocks optimally and return credibly to a long-term prudent level of debt to be able to respond to other negative shocks in the future at the lowest possible cost.

ratio for pricing debt is affected by the debt decision and the credibility stock.[7]

The first-order conditions of the prudent government (the equivalent to Equation (4) of the actual government) are:

$$\frac{\left[C_{PR}^{\sigma}G_{PR}^{(1-\sigma)}\right]^{(1-\theta)}}{G_{PR,t}} = \beta\mathbb{E}_t\left\{\frac{\left[C_{PRt+1}^{\sigma}G_{PR,t+1}^{(1-\sigma)}\right]^{(1-\theta)}}{G_{PR,t+1}}\right\}(1+i_{PR,t}^{G\star})(1+\eta\nu_{t-1}\frac{D_{PR,t}^{\star}}{Y_t}) \tag{14}$$

$$\tau Y_t + D_{PR,t}^{\star} = G_{PR,t} + D_{PR,t-1}^{\star}(1+i_{PR,t-1}^{G\star})$$

where all the variables with sub-index PR refer to the variables of the economy when the government acts prudently.

Compared to Equation (4), Equation (14) has an additional term $(1+\eta\nu_{t-1}\frac{D_t^{\star}}{Y_t})$, which captures the idea that the government considers the impact of its debt on its borrowing costs in its intertemporal decision. More precisely, an increase in the debt-to-GDP ratio results in an interest rate $\eta\nu_{t-1}$ times higher. This modified equation, together with the respective budget constraint, is needed to obtain the optimal debt path that leads to a prudent debt ratio in $t+k$. In that sense, the former is the path the government constrained by this first rule commits to and the latter is the announced target.

Additionally, it is important to keep in mind that when the government is prudent (i.e., its Euler equation is given by (14)), the corresponding credibility index and interest rate will be different from those of the actual government. As all macroeconomic variables are endogenous to the government's actions and vice versa, when the government behaves prudently it leads to a different equilibrium. Therefore, to retrieve the adequate target and limits for the first fiscal rule, one must take into account the complete prudent economy's equilibrium from t to $t+k$. In short, the limits for the rule will be given by $\overline{d_t^{PR,i}} = \frac{D_{PR,i}^{\star}}{Y_i} \quad \forall i \in \{0,...,k\}$. The prudent government problem is presented in Appendix 6.2.

After obtaining the numerical values for the constraints that will be imposed on the actual government when the fiscal rule is in place, one must solve the actual government's problem constrained with the rule:

$$\max_{\{G_t,D_t^{\star}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} {\phi_t}^t \, \frac{(C_t^{\sigma}G_t^{1-\sigma})^{1-\theta}}{1-\theta}$$

subject to:

$$G_t + D_{t-1}^{\star}(1+i_{t-1}^{G\star}) \leqslant \tau Y_t + D_t^{\star}$$

$$d_{t+i}^{\star} \leq \overline{d_t^{\star,PR}} \quad \forall i \in \{0,...,k\}$$

[7]The prudent government assumes that credibility will be held constant at the moment investors price its debt in the market, so it does not take the derivative of the credibility stock against the debt level. We assume that the the long-run debt target for the prudent government is constant.

In this case the FOC are:

$$(1-\sigma)\frac{\left[C_t^{\sigma}G_t^{(1-\sigma)}\right]^{(1-\theta)}}{G_t} - \frac{\mu_t^{PR}}{Y_t} = \mathbb{E}_t\left\{\phi_t(1+i_t^{G\star})\frac{\left[C_{t+1}^{\sigma}G_{t+1}^{(1-\sigma)}\right]^{(1-\theta)}}{G_{t+1}}\right\} \tag{15}$$

$$\mu_t^{PR}\left(\frac{D_t^{\star}}{Y_t} - \overline{d_t^{\star,PR}}\right) = 0 \tag{16}$$

$$G_t + D_{t-1}^{\star}(1+i_{t-1}^{G\star}) = \tau Y_t + D_t^{\star}$$

where μ_t^{PR} is the Lagrange multiplier associated with the debt target rule in period t. When the prudent debt path of this first fiscal rule is binding, $\mu_t^{PR} \neq 0$, which implies from (16) that $d_t^{\star} = \overline{d_t^{\star,PR}}$, making the debt level chosen by the government consistent with that of a prudent government. This is achieved by the extra-term that appears in the intertemporal condition (15).

2.5.2 Fiscal Rule 2: Government's Deficit Bias and the Operational Rule

The second fiscal rule can be thought of as the so-called operational rule in the IMF's *two-pillar approach* to the extent that it explicitly sets a limit on government's fiscal balance period by period. This rule works as a constraint on the fiscal balance to prevent overspending by an incumbent government with deficit bias. The rule is defined by the following constraint:

$$\frac{G_t + i_{t-1}^{G\star}D_{t-1}^{\star} - \tau Y_t}{Y_t} \leq \overline{BBY_t} \tag{17}$$

where $\overline{BBY_t}$ is the imposed limit on fiscal balance as a percentage of GDP. It is worth mentioning that in this model, imposing a cap on the fiscal balance is equivalent to limiting public spending because the tax rate τ is assumed to be invariant and revenue is exogenous, varying with the endowment's fluctuations. In other words, we do not allow for tax reforms every period, and therefore, any fiscal adjustment that comes from the rule is implemented through changes in expenditures.

The value of $\overline{BBY_t}$ is chosen from the problem of a government that does not feature a deficit bias and, thus, its decisions are not time-inconsistent. We call this government *non-distorted* (ND) and it solves the problem presented in 2.3, but with a constant discount factor set equal to that of households: $\phi_t = \beta$, $\forall\ t \in [0, \infty)$.[8,9]

[8] Details about the complete equilibrium of the non-distorted government are found in 6.1.

[9] Note that this non-distorted version of the model is the one used to calculate the OAF_t in Equation (7). Given that the fluctuations in the endowment are identical for the biased government and that credibility varies as long as public debt is used to smooth out the cycle, all discrepancies between $d_t^{\star}$ and $d_{ND,t}^{\star}$ can be attributed to the deficit-bias distortion.

The fiscal balance limit set by the operational rule is that a government would optimally choose in the absence of a deficit bias: $\overline{BBY_t} = \frac{G_{ND,t} + i^{G\star}_{ND,t-1} D^{\star}_{ND,t-1} - \tau Y_t}{Y_t}$. Hence, the government's problem becomes:

$$\max_{\{G_t, D^{\star}_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} {\phi_t}^t \, \frac{(C_t^{\sigma} G_t^{1-\sigma})^{1-\theta}}{1-\theta}$$

subject to:

$$G_t + D^{\star}_{t-1}(1 + i^{G\star}_{t-1}) \leqslant \tau Y_t + D^{\star}_t$$
$$\frac{G_t + i^{G\star}_{t-1} D^{\star}_{t-1} - \tau Y_t}{Y_t} \leq \overline{BBY_t}$$

The optimality conditions of the government's problem when subject to an operational rule are given by:

$$\left[(1-\sigma)\frac{\left[C_t^{\sigma} G_t^{(1-\sigma)}\right]^{(1-\theta)}}{G_t} - \frac{\mu_t^{ND}}{Y_t}\right] = \mathbb{E}_t\left\{\phi_t(1+i_t^{G\star})\frac{\left[C_{t+1}^{\sigma} G_{t+1}^{(1-\sigma)}\right]^{(1-\theta)}}{G_{t+1}} - \frac{\mu_{t+1}^{ND}}{Y_{t+1}}\right\} \tag{18}$$

$$\mu_t^{ND}\left(\frac{G_t + i^{G\star}_{t-1} D^{\star}_{t-1} - \tau Y_t}{Y_t} - \overline{BBY_t}\right) = 0 \tag{19}$$

$$G_t + D^{\star}_{t-1}(1 + i^{G\star}_{t-1}) = \tau Y_t + D^{\star}_t$$

with μ_t^{ND} being the Lagrange multiplier associated with the operational fiscal rule. Equation (18) determines the optimal intertemporal decision of a deficit-biased government constrained by a budget balance fiscal rule, and Equation (19) is the Kuhn-Tucker condition of the second rule. When $\mu_t^{ND} \neq 0$, the second fiscal rule is binding, and if so, the optimal intertemporal spending decision of the government in Equation (18) is constrained.

2.5.3 Combination of Fiscal Rules

Finally, the two rules can be implemented at the same time. As each rule is targeting a different distortion, it is possible that welfare improves by implementing both as opposed to just one. Because the first fiscal rule is forward-looking and uses the announcement of a new debt target as an instrument, the two rules do not seem redundant. However, at any given time t by pure accounting, setting a cap on the fiscal balance should be equivalent to setting a limit on the debt. Therefore, at a given t, there will probably be just one binding rule, the one that is more strict. The problem is given as follows:

$$\max_{\{G_t, D^{\star}_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} {\phi_t}^t \, \frac{(C_t^{\sigma} G_t^{1-\sigma})^{1-\theta}}{1-\theta}$$

subject to:

$$G_t + D^\star_{t-1}(1 + i^{G\star}_{t-1}) \leqslant \tau Y_t + D^\star_t$$
$$d^\star_t \leq \overline{d^{\star,PR}_t}$$
$$\frac{G_t + i^{G\star}_{t-1} D^\star_{t-1} - \tau Y_t}{Y_t} \leq \overline{BBY_t}$$

And the corresponding optimality conditions are given by:

$$(1-\sigma)\frac{\left[C^\sigma_t G^{(1-\sigma)}_t\right]^{(1-\theta)}}{G_t} - \frac{\mu^{ND}_t + \mu^{PR}_t}{Y_t} = \mathbb{E}_t\left\{\phi_t(1+i^{G\star}_t)\frac{\left[C^\sigma_{t+1} G^{(1-\sigma)}_{t+1}\right]^{(1-\theta)}}{G_{t+1}} - \frac{\mu^{ND}_{t+1}}{Y_{t+1}}\right\} \quad (20)$$

$$\mu^{PR}_t \left(\frac{D^\star_t}{Y_t} - \overline{d^{\star,PR}_t}\right) = 0 \quad (21)$$

$$\mu^{ND}_t \left(\frac{G_t + i^{G\star}_{t-1} D^\star_{t-1} - \tau Y_t}{Y_t} - \overline{BBY_t}\right) = 0 \quad (22)$$

$$G_t + D^\star_{t-1}(1 + i^{G\star}_{t-1}) = \tau Y_t + D^\star_t$$

Equation (20) shows that when any of the fiscal rules is binding, the optimal intertemporal decision will be constrained. Furthermore, from this equation, one can see that the more restrictive constraint over the fiscal balance will be the one that will be relevant in period t. However, the non-binding fiscal rule can also be in play by modifying debt targets, the credibility stock, and expectations.

To provide some intuition as to why having a combination of fiscal rules could be better than just having one, one should note that offsetting the effect of one distortion does not necessarily guarantee that the effects of the other distortion are reduced. For instance, the operational rule shoud improve fiscal credibility by setting the OAF_t to 1 and by having a lower deficit. Nonetheless, this does not necessarily lead to the debt-to-GDP ratio or the credibility stock that a prudent government would seek to achieve. Similarly, having more prudent debt levels going forward after an adverse shock does not imply that the $OAF_t = 1$, because a prudent government will not be immune to political economy pressures and foreign investors will not price sovereign debt today as if the government behaved time-consistently and with no deficit bias.

2.6 Parametrisation

To show the main channels in the model and how fiscal rules operate, we use some parametrisation of the model that satisfies the equilibrium defined in 2.4.1.

Parameter	Value	Description
β	0.9524	Household discount factor
σ	0.8421112	Private consumption share in U(.)
τ	0.3	Endowment tax rate
η	0.025	Foreign interest rate elasticity
θ	4.15	Relative risk aversion coefficient
ρ^Y	0	Productivity shock persistence
ρ^ν	0.15	Credibility stock persistence

Following International Monetary Fund (2021), Congressional Budget Office (2021), and Organisation for Economic Co-operation and Development (2021), in the model simulations of next section, mid-term is assumed to be five years ahead. The maximum debt level is chosen to reflect, in steady state, the average fiscal space for the emerging Latin American economies considered in Méndez-Vizcaíno & Moreno-Arias (2021).

Parameter	Value	Description
$\bar{Y}$	1	Income endowment
$\bar{\phi}$	0.9524	QH discount process
$\bar{i}^{G\star}$	$\frac{1}{\bar{\phi}} - 1 = 0.05$	Public debt interest rate
$\bar{i}^{p\star}$	$\frac{1}{\bar{\beta}} - 1 = 0.05$	Private debt interest rate
$\bar{D}$	0.25	Long-run public debt-GDP target
D^{Max}	0.5	Long-run maximum public debt-GDP
$\bar{B}$	0.3	Long-run private debt-GDP target
$\bar{RF}$	$\bar{i}^{G\star}$	Risk-free interest rate

3 Results

In this section, we perform simulations that illustrate the mechanisms of the model and allow us to investigate the welfare losses that the distortions of the economy bring about, and the benefits of the fiscal rules proposed. To keep the simulations tractable and better understand the mechanisms through which distortions and rules operate, we first analyse deterministic simulations with MIT shocks that occur only in the first year. In particular, we consider a case in which the economy receives a transitory negative output shock of 1% and the government surprisingly increases its discount rate from 5% to 8.5%. Then, a simulation of a more extreme case in which the government's discount rate rises up to 12% is performed in order to study how the size of the deficit bias can change the benefits of the different fiscal rules given the non-linearity of the model. Later in the section, for robustness, an analysis is performed with two hundred-period simulations, where innovations for both output and the government's discount factor are randomly drawn from their distributions and used as MIT shocks that sequentially surprise agents in each period.[10]

The simulations are performed under different setups of the model to explain the mechanisms of the distortions and the fiscal rules. First, we shock the simplest version of the model, in which there are no distortions. This is what we call the RBC case, which will serve as the benchmark to compare the outcomes of the other cases.[11] Second, the economy featuring the actual government (the one presented in 2.3) with variable credibility and time inconsistency is simulated. Third, we compare the latter to the cases in which the government is constrained by each fiscal rule, one at a time, and evaluate their individual impact on macroeconomic dynamics and welfare. Lastly, the model is simulated when the government is simultaneously constrained by the two fiscal rules; we then compare this to the RBC case to see if the combination of rules brings the economy back to the benchmark. All the cases and their descriptions are summarised in Table 3.

Table 1: Simulation Cases and Description

Case	Fiscal Rule	Description
RBC	No	Benchmark case: No deficit bias and constant, perfect credibility
Both Distortions	No	Deficit bias and variable credibility
Debt Target Rule	Yes	Both Distortions + fiscal rule of prudent government
Operational Rule	Yes	Both Distortions + fiscal rule of non-biased government
Combined Fiscal Rules	Yes	Both Distortions + Both Fiscal Rules

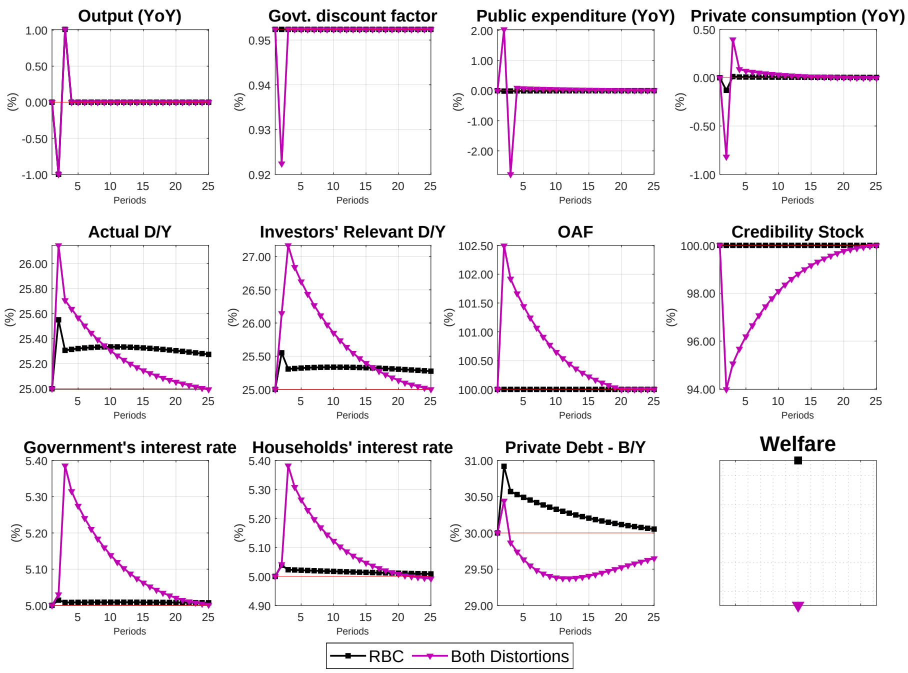
Figure 3 compares the economy's dynamics under the first two cases in response to the shocks and illustrates how the two distortions influence the government's decisions and the economy's equilibrium. In the absence of a deficit bias, the government will smooth out part of the negative output shock by taking some debt and will cut its public expenditure by less than what its income fell. Households will also try to smooth out the impact of the shock by borrowing. When the government exhibits deficit bias, its expenditure moves in the opposite direction. This excess spending makes credibility to fall steeply because it entails issuing more debt and because foreign investors interpret the dynamic inconsistency as a source of

[10]This simulation strategy builds on the ideas laid out in Boppart et al. (2018), where they use MIT shocks as numerical derivatives of a nonlinear model in sequence space. We use this notion to solve our model nonlinearly, which is required to implement the constraints, and perturb it. Also, with this approach we can exploit the deterministic nature of the method to interpret the first rule as actual announcements known to all agents. In this way, we can chain the deterministic transition paths obtained after each new MIT shock, while still managing to "surprise" the agents in the model with the realisation of unanticipated shocks to the endowment and the government's discount factor.

[11]Note that we take the RBC as a benchmark because it is the case where there are no distortions. However, this version of the model does not correspond to the first-best scenario since government is still a political one, and not a central planner. Therefore, it is possible to improve welfare above that of the RBC.

future overindebtedness (notice the OAF panel in the figure). The higher the investor's relevant debt-to-GDP ratio, stemming from both, higher debt and lower credibility, causes the interest rate on public debt to increase fast. The higher interest rate faced by the government is passed through to consumers, who now face higher borrowing costs, and this results in a lower ability to smooth out the shock and a crowding-out of private consumption and debt.

Figure 2: The Effects of the Distortions

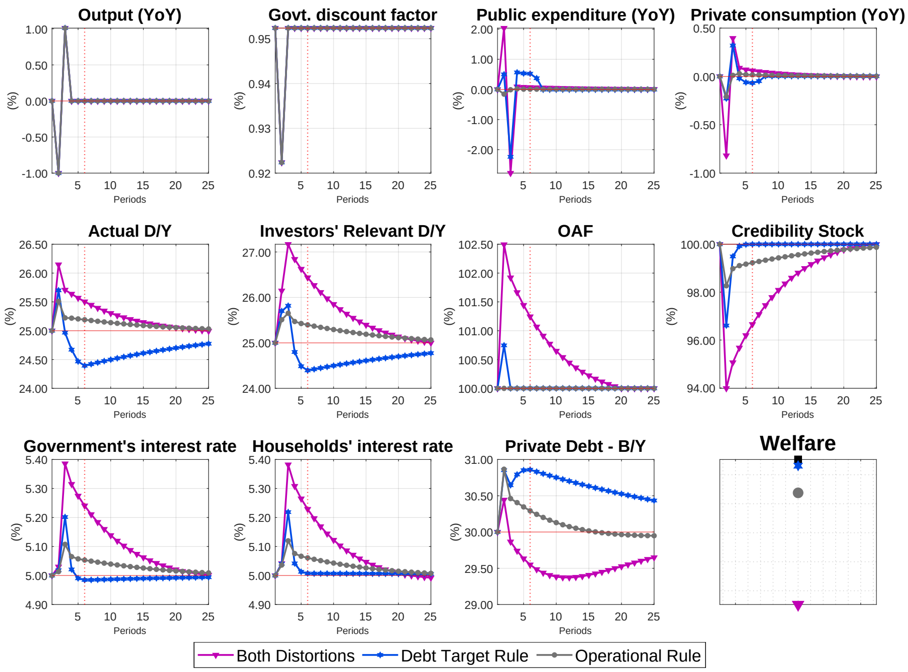


Moreover, because the government increased public consumption during a bust, its next year's debt service becomes too costly and puts pressure on the fiscal balance. Consequently, in year two, it has to cut its spending by more than what it has increased it in the previous year. In spite of improving the primary balance, the credibility stock and interest rate are unfavourable to drive the debt-to-GDP ratio back to its steady state level faster. The prolonged higher financing costs prevent public and private spending to make up for the reductions experienced in the first couple of years. These lower levels of spending flows over the simulation horizon with respect to the RBC explain the welfare loss of the scenario that we have named *Both Distortions* (see last panel in the figure).

The next set of simulations introduces fiscal rules with the goal of offsetting the welfare losses generated by time-inconsistent spending and higher interest rates caused by lower credibility. Figure 3 shows the results comparing the economy's dynamics when each of the rules is implemented separately with the *Both Distortions* case. Because the government's dynamic inconsistency is a key source of the credibility loss, one could think that the operational fiscal rule would suffice to restore the economy's welfare. However, this is not the case, and it is the debt target rule that recoups a larger share of the initial welfare loss, despite featuring a greater fall of the credibility stock on impact.

The different welfare effects of the fiscal rules have to do with how they operate along the cycle. While the debt target rule reduces the propagation of the distortions over time, the operational rule removes a great deal of their amplification by preventing the government from over-spending in the short run. To better understand this point, let us turn to each rule and explain how their implementation affects the economy.

Figure 3: The Mechanisms of Each Fiscal Rule



The debt target rule has an important dynamic and forward-looking component. According to the rule, after the shock, the government announces a debt target that it will strive to attain in the following five years. In the case of the simulation shown, after increasing the debt level in response to the shock, the new target level is below the long-run value because a prudent government knows it can directly affect the interest rate and make up for the high financing costs of today by over-correcting its debt path in the years to come. Importantly, the government will commit to following a debt path over the following 5 years that in the absence of new shocks will ensure it gets to the announced target optimally. The fact that the medium-term debt target is below the long-run target lowers credibility because it looks harder to attain. Hence, under the debt rule, today's credibility falls significantly, although less than when there is no rule. In fact, if the government does not commit to a debt path consistent with its announcement from the start, credibility would fall even more than in the *Both Distortions* scenario and converge in a later period. This means that the power of this first fiscal rule lies in announcing the target along with a consistent path and sticking to it from the beginning (notice how the actual debt-to-GDP ratio is a bit lower in the first year under this rule than without it). In this sense, albeit it constrains the government from year one, the debt target fiscal rule is forward-looking and its benefits come from reducing the propagation of shocks and their distortion-induced amplified effects over time after the economy is shocked. The rule works mainly because it has the effect of restoring credibility fast, much faster than when there are no rules and when there is only the operational rule.

In contrast, the operational rule focuses more on the short-run spending decisions and tackling the distortion stemming from the desire of the government to overspend today in response to political economy pressures. Therefore, the implementation of this rule requires authorities to calculate the fiscal balance that would be optimal each year if the government was time-consistent. In the model and the simulation, this implies that the rule establishes that the maximum spending level at any given time t is the one determined by the government's Euler equation (Equation (23)) when the discount factor is constant, given the same vector of state variables.[12]

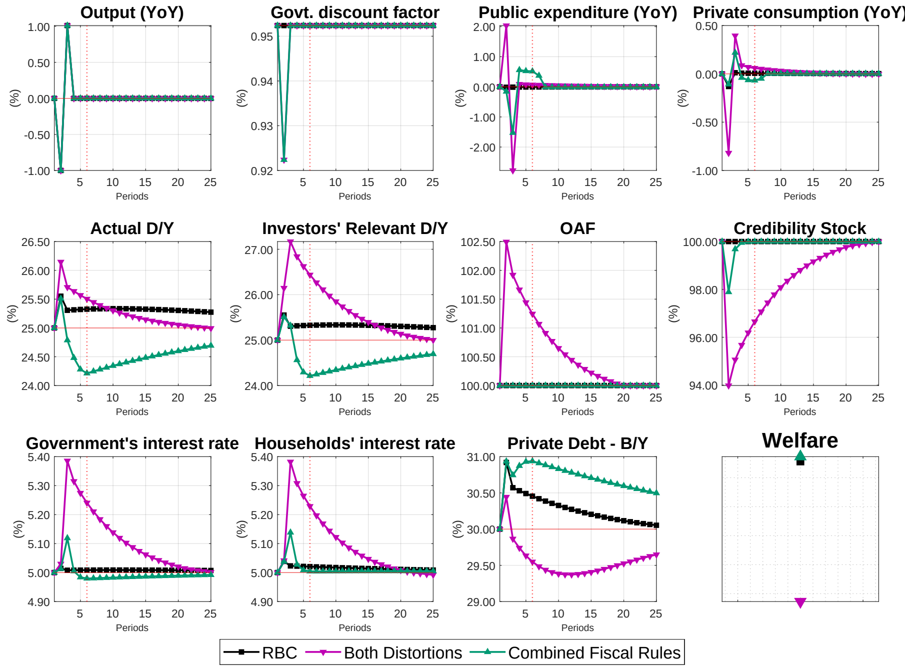
By controlling over-spending, the operational rule forces the government to cut spending in response to its revenue decline and limits how much debt it can use to smooth out the negative income shock. This moderates the initial jump in the debt-to-GDP ratio and, by making the proper spending adjustment, signals foreign investors that the government is more determined to be fiscally responsible ($OAF_t = 1$). Together, these elements make credibility to fall modestly and interest rates to remain close to their steady-state values.

Despite dampening the amplification that the spending bias brings after a negative income shock and improving welfare, the operational rule does not achieve as big as an improvement as the debt rule. This is because it does not induce the forward-looking saving behaviour of the debt target rule. As a consequence, the government never drives the cost of servicing the debt below its steady-state value to make up for the initial increase, thereby preventing the economy's spending level to converge from above and regain some of the flows lost when output dropped. This is reflected in the behaviour of the credibility stock, which takes many periods to be restored.

Moreover, neither of the two rules singularly induces sufficient adjustments to completely offset the welfare losses from the shock and the distortions, begging the question as to whether the combination of the two rules may yield higher welfare gains than each rule separately. The simulation of the economy that implements the combination of the debt target rule and the operational rule is shown in Figure 4 and compared to the two extreme cases considered: RBC and *Both Distortions*. First, notice that the economy's welfare is better when the government is simultaneously constrained by the two rules than by each rule separately and in this case, even surpasses that of the RBC case.

[12] In a more realistic setting, in which tax rates can change over time, the rule would set the fiscal balance limit and there could be multiple combinations of spending and tax decisions that make the constraint hold, but the government's Euler equation will still be a crucial equation to determine the optimal budgetary arrangement to meet said rule.

Figure 4: The Combination of Fiscal Rules



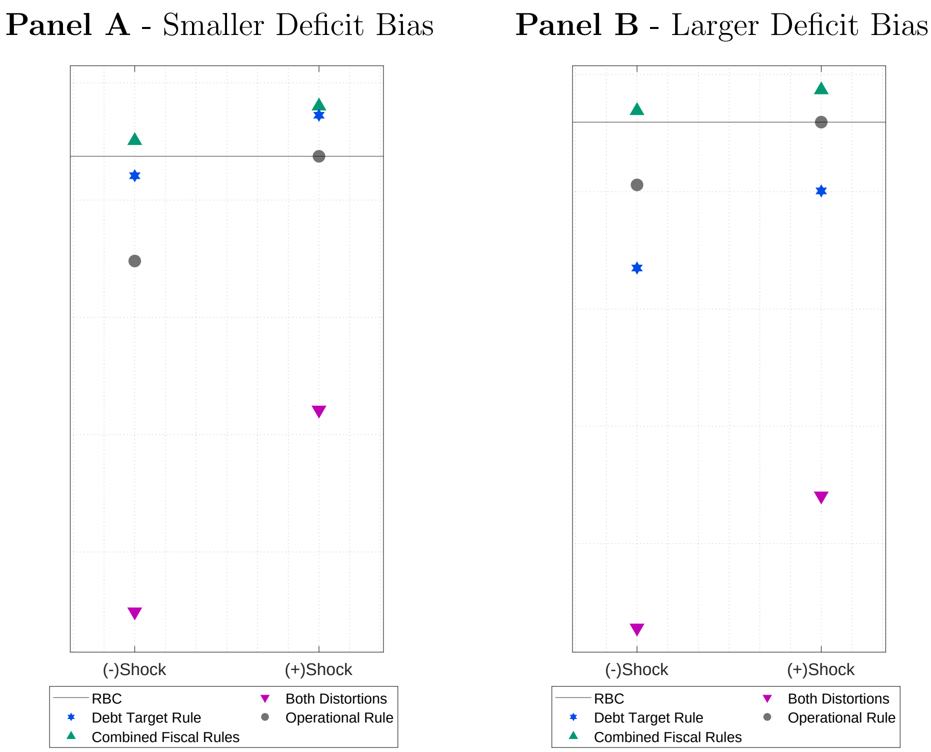
Second, when choosing between the two rules, a trade-off emerges between the amplification of the shock on impact and the propagation of its effects over time through the evolution of the credibility stock and the interest rate paths. If the rules are combined, this trade-off is optimally resolved and allows the government to smooth out a greater share of the output shock at a lower cost. Initially, the operational rule prevents the deficit bias from materialising on the spending decision, and this keeps the OAF perfect, thereby minimising the credibility loss in year one without avoiding it completely. This is because, even in absence of deficit bias, the political government is still trying to maximise household utility through public spending and their risk aversion provides an incentive for the government to smooth the negative output shock with some debt. Furthermore, because it is announcing a prudent debt path and giving some signal of commitment from today, agents expect the government to rapidly regain its credibility. The short-run restrictions from the operational rule lessen the effects of distortions, thereby reducing the spending cuts needed with the debt target rule to minimise the propagation of the shock over time from that point onward.

Although the constrained government would not smooth out a great deal of the income shock, which explains why the green line shows public expenditure falling for a couple of periods after the shock, the fact that the denominator is falling increases the debt-to-GDP ratio and causes a credibility loss on impact. The said loss is worsened on impact by the fact that the debt target rule sets the target below the steady-state ratio. However, the lower target is chosen by the forward-looking, prudent government as it is trying to decrease future financing costs to sustain higher public consumption levels once the negative shock dissipates.

In addition, notice that from the fourth year onward, public expenditure growths at higher rates than in the other two cases. This happens because the debt target rule drives the government towards a lower debt-to-GDP ratio while simultaneously regaining perfect credibility and causing the interest rate to fall below its steady state. The low interest rate frees up fiscal revenue to be spent in public goods and services. Additionally, the lower public financing costs translate into lower costs for the private sector, thus minimising the crowding out effect seen in the *Both Distortions* case. Notably, over the simulation horizon, the private debt-to-GDP path stays higher when rules are combined than in the RBC case.

One conclusion that follows from the aforementioned analysis, under the different cases, is that when the economy receives a negative shock that induces the government to increase its debt, it will result in a reduction of credibility. But, what happens after a positive shock? In principle, even without an active fiscal rule, a positive output shock would enable the government to repay its debt, thus improving its credibility or keeping it perfect and allowing interest rates to stay low. This opens up the question regarding if the welfare ordering of the scenarios when the output shock is negative holds when the shock is positive.

Figure 5: Welfare Outcomes: Negative vs. Output Shock



Panel A of Figure 5 shows the welfare of the different model cases after positive and negative output shocks. The welfare losses from the distortions and the relative gains from the fiscal rules, both separately and combined, are not symmetric when the sign of the output shock changes. The *Both Distortions* scenario is not as detrimental with a favourable income shock as with the adverse shock. This is the case because credibility losses are less severe, given that public debt will not be as far from its target when the government has additional resources to finance its expenses and even repay some debt.[13]. The most harmful distortion when revenue is on the rise is the deficit bias. The bias increases public expenditure and prevents the debt reduction that the government would implement otherwise, yielding a lower credibility stock and higher interest rates. Consequently, the operational rule is sufficient to completely reverse the welfare loss of the distortions, contrary to what happens when output falls.

An important message at this point is that when output falls, neither of the two fiscal rules is sufficient to reach the welfare of the RBC case, and only the combined rules can offset the welfare loss of distortions. In contrast, when output rises, the operational rule is enough to offset the welfare loss from the present bias. Nevertheless, the debt target rule and, especially the combination of them, is still preferred in terms of welfare. When the output shock is positive, higher fiscal revenues coupled with the prudent behaviour induced by the debt target rule lead to a higher welfare than in the RBC case. This happens because the government can take advantage of the positive shock to reduce interest rates more rapidly than when the shock is negative to later sustain even higher levels of public spending. In other words, public spending can be higher than in the RBC case without much crowding out on private consumption, as interest rates will be even lower than in the RBC due to the government's prudent behaviour.

However, these results do not always hold and are sensitive to the size of the deficit bias.[14] As the model features non-linearities, the magnitude of the distortions matters for determining the welfare outcomes of the different cases. In particular, we repeat the same simulations already explained but doubling the deficit bias. The welfare results are summarised in Panel B of Figure 5. Three points are worth highlighting. First, irrespective of the sign of the output shock, the operational rule is now better than the debt target rule. This is in line with the fact that the deficit bias directly deteriorates credibility, and this source of credibility loss is not necessarily contained by the debt target rule. Second, the combination of fiscal rules still dominates all other cases in either a boom or a bust. Third, it is still true that no rule alone is enough to reach the RBC's welfare when output falls, but the operational rule does recoups welfare when output rises. Moreover, when the deficit bias is larger, only the combination of rules is able to improve upon the RBC's outcomes.

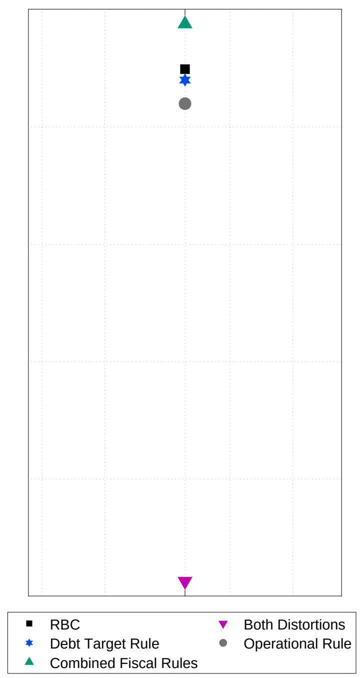
The asymmetric welfare effects of distortions and fiscal rules prompt one to wonder if the same set of results holds for lots of simulations or if the results just presented hold only for particular cases. For that purpose, the model is simulated during 200 periods for the five cases of Table 3. The simulation draws random innovations from the distributions of ε_t^Y and ε_t^ϕ for each period $t \leq 200$. As before, the model is solved in a deterministic setting and perturbed through MIT shocks. In the first period, the agents observe a set of two

[13] The macroeconomic dynamics when the shock is positive are shown in Appendix 6.3.

[14] We also performed sensitivity analyses with the size of the output shock and found that, provided a constant size of deficit bias, the welfare ordering of the cases and the broad messages regarding the gains of each rule did not change. This is reflective of the fact that output is an endowment and, as such, is invariant to the fiscal setup, whereas the deficit bias does change the counterfactual behaviour of the non-distorted and prudent governments used to gauge the limits of each fiscal rule.

unanticipated shocks that perturbs the steady state and foresee no future shocks. This first perturbation yields a sequential equilibrium for the next 100 periods. But in the next period, there is another set of MIT shocks that perturbs the previously computed equilibrium vector for the second period and, once again, a new sequential equilibrium is computed considering no future shocks.[15] This consecutive perturbations through MIT shocks continue for 200 periods. The main advantage of this simulation strategy is that it solves the model with all its non-linearities whilst generating business-cycle-like dynamics. Additionally, notice that chaining the deterministic simulations with MIT shocks favours the interpretation of the debt target rule as an actual announcement made in every period t, known to all agents, of the medium-term target and the debt path the government would follow to reach it in the absence of new shocks.

Figure 6: Welfare Outcomes of the 200-Period Simulations



The welfare outcomes of these simulations are summarised in Figure 6 and more detailed graphs of the macroeconomic dynamics behind them are presented in Appendix 6.3. The first thing that stands out in the figure is that the order of the cases by welfare broadly resembles the orders shown with the single MIT shock simulations. The result for the Combined Fiscal Rules case is probably the most noteworthy, considering it remains as the best welfare scenario. This result only reinforces the lesson that the best possible world with a political government (i.e., in absence of a central planner) is one where a combination of the two fiscal rules is implemented.

[15]Each period, the model is solved with Dynare's perfect foresight solver for a 100-period horizon. Hence, the equilibrium in the period when the first set of MIT shocks is observed becomes the vector of initial values for the new simulation with the second set of MIT shocks. This process is repeated for 200 periods.

Additionally, it is interesting that, despite the asymmetries already pointed out, when the economy is randomly perturbed with shocks of different sizes and sign, the Debt Target Rule improves upon the RBC and the Operational Rule-only cases. The debt target rule offers better results along business cycles due to its more forward-looking design, inasmuch as it will induce a precautionary saving-like behaviour, both in terms of debt and credibility: prudent behaviour allows the government to be in better shape to respond when the next shock arrives. Thus, the random output shocks will be better buffered when the government is constrained to act prudently than when it is only limited by the current size of its deficit. Moreover, because output impacts the debt-to-GDP ratio both on the numerator (smoothing-motive) and the denominator, signalling prudence behaviour will allow the government to mitigate credibility losses and keep interest rates low while allowing the government to spend more on average.

Nonetheless, the debt target rule is still inferior than the combination, which shows that over-spending is still an issue at some points. When the political economy pressures captured by the discount factor randomly fluctuate along the horizon and peaks of deficit bias can coincide with output busts, the debt target rule loses power. It is less welfare improving because large deficit biases along the cycle can directly generate large credibility losses on impact, even if a prudent government has previously stocked up on credibility. The combination of the two rules achieves better outcomes by allowing the government to be constrained by the most appropriate benchmark in each period. If the most relevant distortion is the deficit bias, the operational rule will more likely be the applicable constraint. If the bias is not as problematic because of the government receiving more revenue during a boom, or having enough precautionary savings, then the debt target rule would be preferred. Case in point: in the 200-period simulation, the debt target rule constrained the government about 70% of the time, whereas the operational rule did it for 30% of the time.[16]

4 Conclusion

In this paper we propose a SOE general equilibrium model to study the welfare effects of constraining the government with a debt anchor fiscal rule and/or a balanced budget rule. The model allows us to evaluate whether and why combining two fiscal rules may be welfare improving and, thus, better than having no rule or just one rule. The model features two frictions generating suboptimal fiscal responses, so that the purpose of implementing fiscal rules is to try to offset the welfare losses.

The first friction is a market one: variable, imperfect credibility about the government's capacity to repay its debt. When foreign investors observe that public debt is getting far above its target, they believe that it is increasingly harder for the government to make the proper adjustment and less likely that it can follow a path of fiscal balances that can reduce debt. The economy's interest rates are higher when fiscal credibility is not perfect. The

[16] The time both rules constrain the government does not necessarily add up to the total length of the simulation horizon, given that the government can at some point be unconstrained if its desired debt level is below either of the two limits.

fiscal adjustment needed to repay debt at high interest rates is harmful for the economy as it requires more resources flowing from the local economy to international markets. Therefore, to improve credibility in the mid-term, while reducing financing costs for both the public and private sectors, a debt target rule can guide government's behaviour towards one of a prudent government that internalises the effect of its debt decision on interest rates.

The second friction is related to a distortion altering the government's decisions. The government is present-biased and incurs in time-inconsistent behaviour that leads to deficit bias and public overindebtedness. Eventually, the fiscal adjustments needed to repay high debt levels are not optimal, as households prefer smooth consumption paths. Additionally, having a deficit bias is perceived by foreign investors as another factor hindering government's credibility. Then, an operational fiscal rule that sets a cap on the fiscal deficit contains government from over-spending in the short-run and from acquiring an excessive debt level, thus improving credibility.

Our simulations show that each rule improves welfare by itself, but each one has a distinct effect on credibility and fiscal behaviour. Whilst the debt anchor rule contains the propagation of the negative effects of an imperfect credibility, the operational rule withholds the amplification of distortions derived from a time-inconsistent government. Moreover, the relevance of each rule varies with the sign of the income shock and the size of the deficit bias because there is an asymmetry between the propagation and amplification of the distortions' effects on macroeconomic dynamics. Hence, our framework suggests that the implementation of a combination of fiscal rules is optimally preferred over one single rule, inasmuch as one rule cannot perfectly offset the two distortions.

The framework developed in this paper can be further extended in some dimensions. First, one could consider a production economy with capital instead of an endowment economy, as this would allow one to explore how a prudent government might favour investment in physical assets. Second, modelling a local market for public debt and an endogenous exchange rate to capture the valuation effects on foreign debt, might shed light on other channels through which a precautionary, sustainable fiscal behaviour could be beneficial. Third, including hand-to-mouth consumers would make public consumption more valuable and thus, offer more robust conclusions about the convenience of fiscal rules. Lastly, because our model embeds the two counterfactual cases needed to set the limits for each fiscal rule, it can be potentially used to help determine the numerical limits in practice and update them as the economic conditions change. More importantly, our proposed framework and analysis are a novel alternative to thinking about how to optimally design and calibrate fiscal rules, as well as if, how, and why a country may want to have more than one fiscal rule.

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6 Appendix

6.1 Non-distorted government

There is an alternate version of the government's problem in which the discount factor is always constant and equal to that of households: $\phi_t = \beta$, $\forall\ t \in [0, \infty)$. All the variables related to this case will have the subscript ND.

$$\max_{\{G_{ND,t};D^{\star}_{ND,t}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta\ \frac{(C^{\sigma}_{ND,t} G^{1-\sigma}_{ND,t})^{1-\theta}}{1-\theta}$$

subject to its budget constraint:

$$G_{ND,t} + D^{\star}_{ND,t-1}(1 + i^{G\star}_{ND,t-1}) \leqslant \tau Y_t + D^{\star}_{ND,t}$$

This government's problem is useful to derive the macroeconomic dynamics that will prevail when the government is always time-consistent and to gauge the welfare losses brought about by the deficit bias. The first-order conditions of this fictitious government are:

$$\frac{\left[C^{\sigma}_{ND,t} G^{(1-\sigma)}_{ND,t}\right]^{(1-\theta)}}{G_{ND,t}} = \beta \mathbb{E}_t \left\{ (1 + i^{G\star}_{ND,t}) \frac{\left[C^{\sigma}_{ND,t+1} G^{(1-\sigma)}_{ND,t+1}\right]^{(1-\theta)}}{G_{ND,t+1}} \right\} \tag{23}$$

$$\tau Y_t + D^{\star}_{ND,t} = G_{ND,t} + D^{\star}_{ND,t-1}(1 + i^{G\star}_{ND,t-1}) \tag{24}$$

Rest of the non-distorted case economy

$$\frac{\left[C^{\sigma}_{ND,t} G^{(1-\sigma)}_{ND,t}\right]^{(1-\theta)}}{C_{ND,t}} = \beta \mathbb{E}_t \left\{ (1 + i^{P\star}_{ND,t}) \frac{\left[C^{\sigma}_{ND,t+1} G^{(1-\sigma)}_{ND,t+1}\right]^{(1-\theta)}}{C_{ND,t+1}} \right\} \tag{25}$$

$$(1-\tau) Y_t + B^{\star}_{ND,t} = C_{ND,t} + B^{\star}_{ND,t-1}(1 + i^{P\star}_{ND,t-1}) \tag{26}$$

6.2 Prudent government

$$\max_{\{G_{PR,t};D^{\star}_{PR,t}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta\ \frac{(C^{\sigma}_{PR,t} G^{1-\sigma}_{PR,t})^{1-\theta}}{1-\theta}$$

subject to its budget constraint:

$$G_{PR,t} + D^{\star}_{PR,t-1}(1 + i^{G\star}_{PR,t-1}) \leqslant \tau Y_t + D^{\star}_{PR,t}$$

and considering its price impact according to:

$$1 + i^{G\star}_t = \left(1 + \frac{\overline{RF}}{\nu_t}\right) e^{\eta\left(I^{d\star}_t - \bar{d}\right)}$$

6.3 Asymmetrical Effects of Fiscal Rules and 200-period Simulation

Figure 7: The Asymmetric Effects of Fiscal Rules

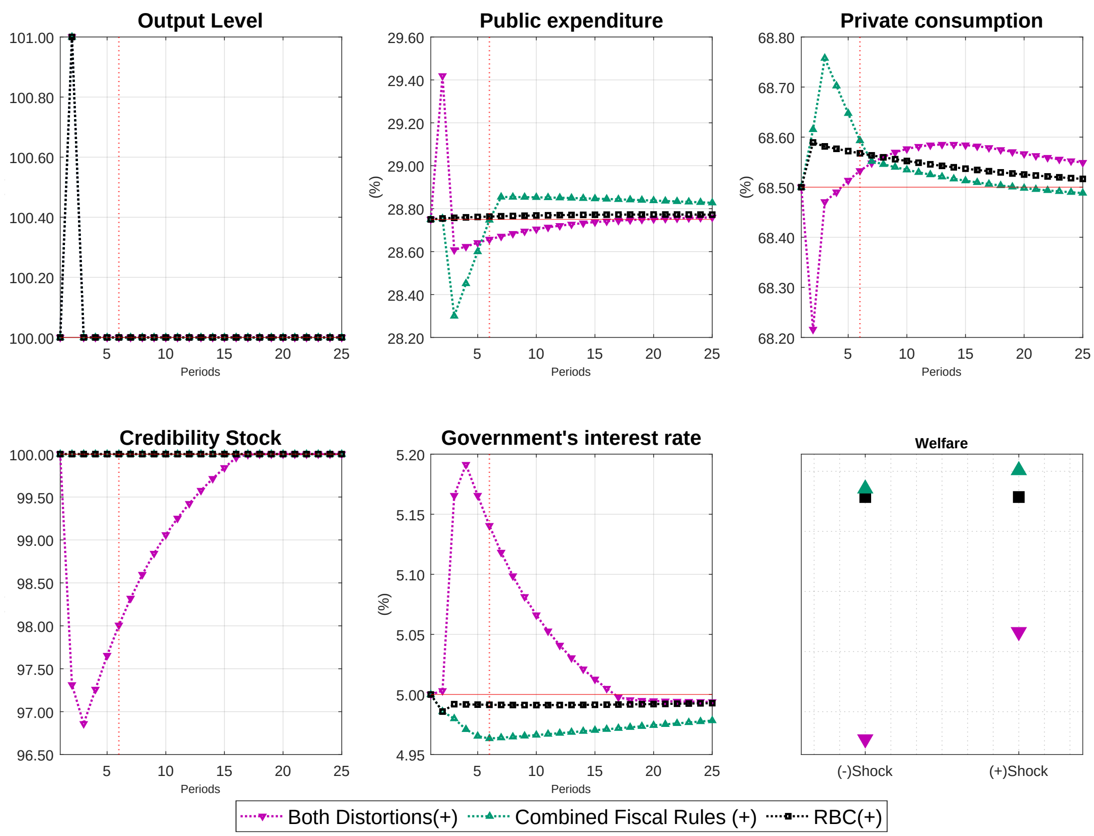

Figure 8: 200-Period Simulation: The Role of Distortions

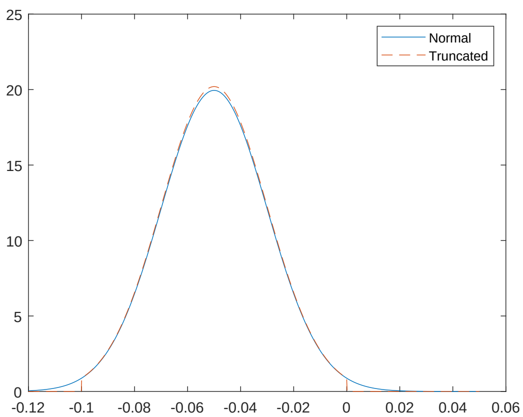

Figure 9: 200-Period Simulation: Individual Fiscal Rules

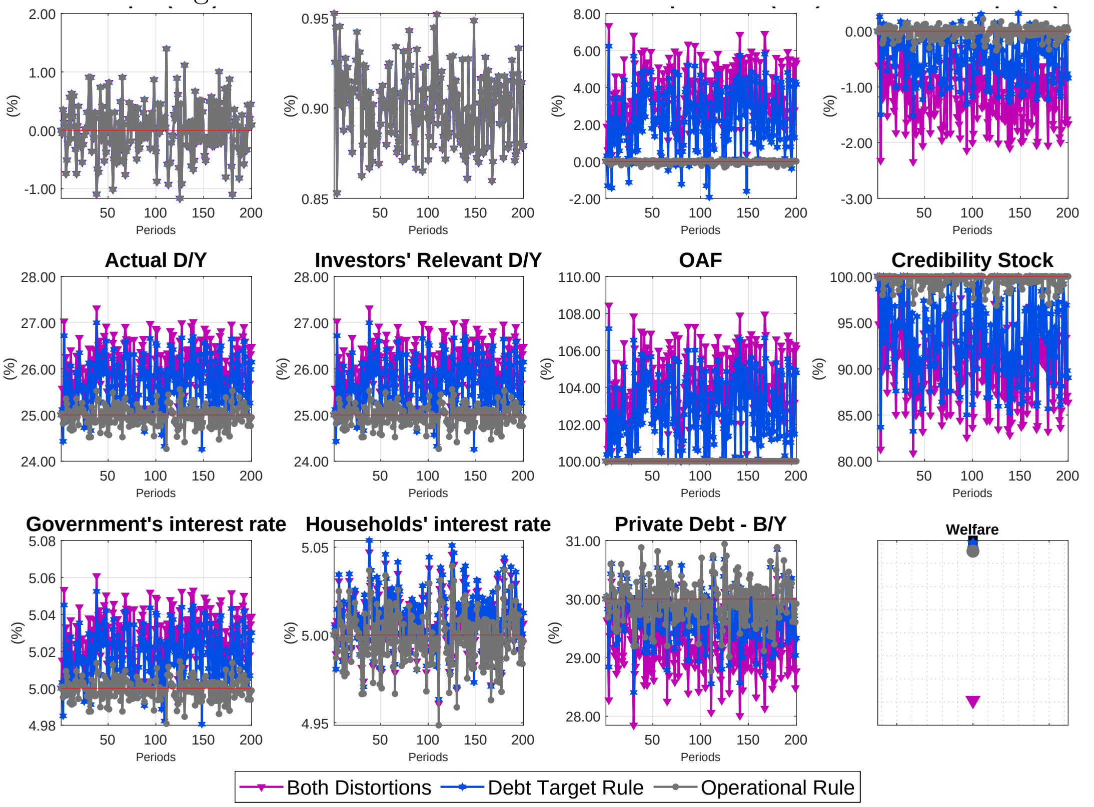

Figure 10: 200-Period Simulation: Fiscal Rules Combination