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How to Starve the Beast: Fiscal Policy Rules

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Abstract

Countries have widely imposed fiscal rules designed to constrain government spending and ensure fiscal responsibility. This paper studies the effectiveness and welfare implications of expenditure, revenue, budget balance and debt rules when governments are discretionary and prone to overspending. The optimal prescription is either an expenditure ceiling or a combination of revenue and primary deficit ceilings. Most of the benefits can still be reaped with constraints looser than optimal or escape clauses during adverse times. When imposed on their own, revenue ceilings are only mildly effective, while budget and debt rules are altogether ineffective.

Keywords: fiscal rules, discretion, time-consistency, government debt, deficit, institutional design, political frictions, austerity, debt sustainability.

JEL classification: E52, E58, E61, E62.

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1 Introduction

Societies have increasingly relied on numerical rules to constrain fiscal policy. Prime examples include the German balanced budget amendment (or "debt brake") and the convergence criteria for joining the Euro. According to the IMF, 105 countries have adopted at least one fiscal rule.[1] These rules "impose a long-lasting constraint on fiscal policy through numerical limits on budgetary aggregates" and aim at "containing pressures to overspend, in particular in good times, so as to ensure fiscal responsibility and debt sustainability."[2]

I conduct a systematic study of fiscal rules and their effectiveness for curbing government spending, and evaluate their macroeconomic and welfare consequences. When fiscal and monetary policies are conducted by a government that is discretionary and prone to excessive spending, the optimal prescription is to either impose an expenditure ceiling or combine revenue and primary deficit ceilings. Both alternatives yield similar welfare benefits (worth about 10% of annual consumption in an economy calibrated to the postwar U.S.) but imply somewhat different long-run policies. Most of the welfare gains from imposing these rules can still be reaped even when they are more loosely implemented or if temporarily suspended in response to adverse shocks. In contrast, a revenue ceiling alone is not as effective in lowering government spending and thus, yields significantly lower welfare gains for private agents. Furthermore, it leads to permanent increases in deficit, debt and inflation. Finally, though widely adopted throughout the world, deficit and debt rules on their own do not succeed in curbing government expenditure.

I study fiscal rules in an economy in which fiscal and monetary policies are jointly determined. The environment is a monetary economy populated by infinitely-lived agents, where a government uses distortionary taxes, fiat money and nominal bonds to finance the provision of a valued public good.[3] The government is not fully benevolent, preferring higher public expenditure than private agents, and lacks the ability to commit to policy choices beyond the current period. Under full discretion, government policy is determined by the interaction of three forces: a motive to smooth distortions, a time-consistency problem and a political friction. The incentive to smooth distortions intertemporally follows the classic arguments in Barro (1979) and Lucas and Stokey (1983). Time-consistency problems arise from the interaction between debt and monetary policy, as analyzed in Martin (2009, 2011, 2013): how much debt the government inherits, affects its monetary policy since inflation reduces the real value of nominal liabilities; in turn, the anticipated response of future monetary policy affects the current demand for money and bonds, and thereby how the government today internalizes policy trade-offs. The political friction creates an upward bias in public expenditure, which has consequences for inflation and taxation; in contrast, debt in terms of output is largely unaffected.[4]

In the absence of aggregate uncertainty, I show that endowing the government with commitment power *at* the discretionary steady state would not prompt a change in policy. Therefore, when starting at the steady state of a non-stochastic economy, all the welfare gains from imposing fiscal rules arise solely from correcting the political friction, by inducing a reduction in

[1] See the IMF Fiscal Rules Dataset and Davoodi et al. (2022).

[2] See Schaechter et al. (2012).

[3] The inclusion of monetary policy in a study of fiscal rules serves a dual purpose. First, as articulated in Martin (2009, 2011), it provides a theory of debt, resulting from the interplay of the incentive to smooth distortions intertemporally and a time-consistency problem due to the response of money demand to policy. Second, it provides the government with an additional (and realistic) channel in which to conduct policy while complying with fiscal rules. On a technical level, it helps avoid potential non-convexities with certain fiscal rules.

[4] An alternative approach would involve a government that is more impatient than private agents, a popular assumption in the political economy and sovereign default literatures. In the context of the model presented here, this alternative implies a very small welfare cost, as it only delays taxation. For example, adding a degree of impatience that would double the debt-GDP ratio in the calibrated economy would rise the potential welfare gains by only 0.4% of consumption. See Martin (2021) for a comparative study of expenditure and debt biases.

government spending or, at least, altering the means by which expenditure is financed. The addition of aggregate uncertainty does not alter this result significantly, as even a discretionary government responds to shocks with sufficient efficiency. In contrast, adopting rules far away from the steady state may have a more significant impact, as the time-consistency problem becomes more prominent.

I evaluate the merits of fiscal rules in an economy calibrated to the U.S. in the postwar period. I also conduct several robustness checks, including a case with a larger (less benevolent) government and one with inflation at current levels rather than the (higher) postwar average.[5] I first study economies without aggregate uncertainty and later add fluctuations in aggregate demand, productivity, public expenditure and liquidity. I assume that shocks are large and rare, but also consider more frequent shocks. The conclusions drawn are robust across all these different specifications.

I rank fiscal rules according to their welfare implications for private agents, relative to the discretionary steady state. When direct constraints on expenditure are not viable and fiscal rules are imposed one at a time, the best prescription is to impose a ceiling on revenue in terms of output. The optimal revenue ceiling is about 15% of GDP, three percentage points lower than with a fully discretionary government. However, revenue ceilings offer welfare gains far from potential and, furthermore, imply a deterioration of macroeconomic performance: debt and inflation increase significantly and output contracts. Budget balance and debt rules, though generally benign, are ineffective, as they fail to lower government expenditure and only manage to alter the policy mix by which it is financed.

I then explore the possibility of combining revenue ceilings with another fiscal rule. There are two effective additions: a primary deficit ceiling (effectively, a balanced budget requirement) and a limit on the growth rate of total government liabilities. The first option, combining revenue and primary deficit ceilings, is preferable. It yields welfare gains for private agents equivalent to 10% of consumption and involves no meaningful transitions; government expenditure falls to benevolent levels, while debt and inflation remain very close to their pre-reform levels. The second option yields slightly lower welfare gains and imposes the gradual and virtual elimination of government debt. Furthermore, it requires high inflation along the transition.

Finally, the best overall prescription is a ceiling on expenditure over GDP of 14.8%, or about three percentage points below the discretionary case. Note, however, that the welfare gains are insignificantly larger than the next best rule, i.e., combining revenue and primary deficit ceilings. Which alternative is preferred may depend on the political viability of constraining expenditures directly.

Severe adverse shocks may require some degree of flexibility, in particular, the relaxation or outright abandonment of pre-existing rules.[6] To address this concern, I extend the quantitative analysis to an economy subjected to aggregate fluctuations and when fiscal rules can be selectively applied or suspended. I consider aggregate shocks to demand, productivity, public expenditure and liquidity, and find that most welfare gains from fiscal rules derive primarily from imposing them in normal times, which also helps discipline government policy during abnormal times. However, the cost of suspending fiscal rules during adverse times are typically minor.

Fiscal rules in practice—There has been widespread adoption of fiscal rules around the world. The vast majority of countries have adopted at least one formal, numerical fiscal target

[5]Throughout most of the paper, I focus on the case when fiscal rules are imposed unannounced, but I also study the case when they are expected to be implemented in the future. From a welfare perspective, private agents always prefer to impose fiscal rules right away.

[6]For example, during the COVID-19 pandemic there was widespread use of escape clauses or *ad hoc* suspension or modification of rules—see Davoodi et al. (2022).

and, in most cases, a combination of multiple rules. Supranational entities also impose fiscal rules on member countries. For example, the European Commission has its own independent advisory board on fiscal matters, which issues annual reports and regular assessments (e.g., see European Fiscal Board, 2019). More broadly, policy rules may also include the fiscal consolidation and austerity programs requested by supranational entities in exchange for economic assistance.

In practice, however, institutional constraints on government policy may not work as intended. Although membership to the Eurozone was granted conditional on meeting explicit convergence criteria, the reality was that many countries did not meet them (Greece being a notable example as it met none of the criteria upon entry—see Martin and Waller, 2012). In the U.S., the debt ceiling has arguably done very little to curtail the recent growth of public debt, which has reached levels not seen since the end of World War II. In contrast, the German amendment seems to have worked as intended, leading to a significant reduction in debt-to-GDP (see Rietzler and Truger, 2018). Sweden is another case of an arguably successful experience with strict fiscal rules—see Andersson and Jonung (2019). The IMF has argued that numerical fiscal rules have been effective at constraining excessive deficits—see Eyraud et al. (2018).

As detailed in Lledó et al. (2017) and Davoodi et al. (2022), most countries have adopted fiscal rules, with budget balance and debt rules being the most common. Only a handful of countries have imposed some kind of revenue rule and, even then, these rules are aimed at constraining revenue growth or tax rate increases. Mostly, the objective is to prevent tax revenue from growing relative to output. Expenditure rules are significantly more common than revenue rules, though, again, most are designed to limit their growth rate relative to output or revenues instead of constraining the level.

Empirical studies on the desirability and effectiveness of "starving the beast" have focused on the effects of tax cuts on output and/or public spending. For U.S. states, Bohn and Inman (1996) find that budget balance requirements have positive effects on surpluses via cuts in spending. At the federal level, Romer and Romer (2009) argue that tax cuts do not restrain government spending, but mostly because these cuts are reversed or counteracted with new taxes soon afterwards. Applying a similar methodology, Cloyne (2013) and Hayo and Uhl (2014) study the effects of tax changes on output in the UK and Germany, respectively. Fuest et al. (2019) consider the recent experience of the German states and find that reductions in tax revenues trigger a fall in public spending, after two or three years.

Fiscal rules in theory—A perennial debate in the design of political institutions is the trade-off between commitment and flexibility, also commonly referred to as rules versus discretion. At the heart of the issue is a time-consistency problem, that is, the temptation to revise *ex ante* optimal policy plans. Allowing policymakers to exercise too much discretion raises the potential for bad policy outcomes, such as, high inflation, large debt accumulation or excessive capital taxation.[7] Unfortunately, forcing policymakers to implement benevolent rules is not straightforward. *Ex ante* optimal policy plans are oftentimes complicated objects that cannot be easily legislated and require a great deal of foreknowledge of all possible future states of the world. There is virtue in simplicity when binding the behavior of future policymakers; simple, straightforward rules are easy to write down and make non-compliance easy to verify.

The macro-theoretic literature has focused on understanding how specific fiscal rules can resolve or mitigate various frictions or biases. Several papers study the desirability of budget balance (deficit) rules. Bassetto and Sargent (2006) show that, under certain demographic conditions, the efficiency of public goods provision can be improved if governments are restricted to finance nondurable goods and services with current revenue and durable goods with debt.

[7]See Kydland and Prescott (1977), Barro and Gordon (1983), Benhabib and Rustichini (1997), Albanesi et al. (2003), Athey et al. (2005), Amador et al. (2006), Martin (2010), among many others.

This rule is similar to that followed by many national governments in the past and most U.S. states today. Alesina and Tabellini (1990) and Niepelt (2004, 2007), among others, motivate why balanced budget requirements may be desirable, despite the fact that they are detrimental for tax-smoothing purposes. Azzimonti et al. (2016) study the impact of balanced budget rules in a political economy model where policy choices are made by a legislature. Though in this setting a balanced budget rule has the potential to be beneficial for private agents, when evaluated at empirical relevant levels of debt, it leads to welfare losses.

There have been some arguments in favor of fiscal rules for countries that form a monetary union. Beetsma and Uhlig (1999) analyze debt bias arising from the fact that shortsighted governments fail to internalize their policy choices; their mechanism provides incentives for governments to sign a fiscal stability pact when in a monetary union, but not otherwise. Chari and Kehoe (2007) argue that in a monetary union, the *ex post* incentives to inflate away nominal debt leads to a free rider problem in fiscal policy, which can be corrected with a debt limit.

Lastly, a series of recent papers study fiscal rules in the context of small open economies. Halac and Yared (2014, 2018) follow a mechanism-design approach to characterize *ex ante* optimal rules which trade off the desire to commit not to overspend with the gains from having flexibility to respond to shocks. They focus on present biased governments and privately-observed value of public spending as the main frictions to overcome. Similarly, Alfaro and Kanczuk (2017) study present biased governments and find that, for emerging countries, a debt rule works close to optimal, while a deficit rule does not perform well. Hatchondo et al. (2017) study fiscal rules that try to mitigate a debt dilution problem that generates a deficit bias; they find that spread brakes are preferable to debt brakes.

The rest of the paper is organized as follows. Section 2 presents the environment and derives optimal behavior by private agents, given government policy. Section 3 studies the determination of fiscal and monetary policy when the government is discretionary. Section 4 defines and analyzes fiscal rules that may be imposed to constrain government behavior. Section 5 describes the quantitative evaluation of the model. Section 6 presents the main results of the paper. Section 7 extends the analysis to stochastic economies and adds the possibility of selectively suspending a rule, depending on the state of the economy. Section 8 concludes.

2 Model

2.1 Environment

The environment extends Martin (2011, 2013, 2015), which study discretionary government policy in monetary economies in the style of Lagos and Wright (2005).[8] Relative to previous work, the setup here allows for the use of public debt as a payment instrument and introduces fiscal rules as potential constraints on government policy.

Consider an economy populated by a continuum of infinitely-lived agents, which discount the future by factor $\beta \in (0, 1)$. Each period, two competitive markets open in sequence, for expositional convenience labeled *day* and *night*. All goods produced in the economy are perishable and cannot be stored from one subperiod to the next.

At the beginning of each period, agents receive an idiosyncratic shock that determines their role in the day market. With probability $\eta \in (0, 1)$ an agent wants to consume but cannot produce the day good x, while with probability $1 - \eta$ an agent can produce but does not want

[8] Most of the analysis and lessons here would carry over to economies with a cash-in-advance constraint or money-in-the-utility function, although at the cost of lower analytical tractability. For a comparison of policies and welfare, with and without commitment, see Martin (2011).

consume. A *consumer* derives utility $u(x)$, where u is twice continuously differentiable, satisfies Inada conditions and $u_{xx} < 0 < u_x$. A *producer* incurs a utility cost $\phi > 0$ per unit produced.

Agents are anonymous and lack commitment. Thus, credit arrangements are not feasible and some medium of exchange is necessary for day trade to occur.[9] Exchange media in this economy takes the form of government-issued liabilities: cash and one-period nominal bonds. Cash is universally recognized and can be used in all transactions. Following Kiyotaki and Moore (2002), assume that agents may pledge a fraction $\theta \in [0, 1)$ of their government bond holdings to finance day market expenditures.

At night, all agents can produce and consume the night good, c. The production technology is assumed to be linear in labor, such that n hours worked produce ζn units of output, where $\zeta > 0$ is common across agents. Assuming perfect competition in factor markets, the wage rate is equal to productivity ζ. Utility at night is given by $\gamma U(c) - \alpha n$, where U is twice continuously differentiable, $U_{cc} < 0 < U_c$, $\gamma > 0$ and $\alpha > 0$. Though a medium of exchange is not essential in this market, agents also trade money and bonds at night.

There is a government that supplies a valued public good g at night. Agents derive utility from the public good according to $v(g)$, where v is twice continuously differentiable, satisfies Inada conditions and $v_{gg} < 0 < v_g$. To finance its expenditure, the government may use proportional labor taxes τ, print fiat money at rate μ and issue one-period nominal bonds, which are redeemable in fiat money. Government policy choices for the period are announced at the beginning of each day, before agents' idiosyncratic shocks are realized. The government only actively participates in the night market, i.e., taxes are levied on hours worked at night and open-market operations are conducted in the night market.[10] The public good is transformed one-to-one from the night good.

Let $s \equiv \{\gamma, \zeta, \theta, \omega\}$ denote the exogenous aggregate state of the economy, which is revealed to all agents at the beginning of each period. The economy is thus subject to a variety of aggregate shocks: demand (γ), productivity (ζ), liquidity (θ) and government type (ω)—the role played by this last parameter will be explained below. The set of all possible realizations for the stochastic state is S. Let $E[s'|s]$ be the expected value of future state s' given current state s.

All nominal variables—except for bond prices—are normalized by the aggregate money stock. Thus, today's aggregate money supply is equal to 1 and tomorrow's is $1 + \mu$. The government budget constraint can be written as

$$p_c(\tau\zeta n - g) + (1 + \mu)(1 + qB') - (1 + B) = 0, \tag{1}$$

where B is the current aggregate bond-money ratio, p_c is the—normalized—market price of the night good c, n in this case refers to aggregate labor, and q is the price of a bond that earns one unit of fiat money in the following night market. "Primes" denote variables evaluated in the following period. Thus, B' is tomorrow's aggregate bond-money ratio. In equilibrium, prices and policy variables depend on the aggregate state (B, s); this dependence is omitted from the notation to simplify exposition.

[9] See Kocherlakota (1998), Wallace (2001), Shi (2006) and Williamson and Wright (2010), among others.

[10] This structure follows Aruoba and Chugh (2010) and Martin (2011). Though exempt here from income taxes, day market activity is nevertheless taxed by inflation. Alternatively, one could impose a uniform tax rate on both day and night income, but at a significant loss in tractability. In the calibration, the day market is about 11% of total GDP.

2.2 Problem of the agent

Let $V(m, b, B, s)$ be the value of entering the day market with (normalized) money balances m and bond balances b, when the aggregate state of the economy is (B, s). Upon entering the night market, the composition of an agent's nominal portfolio (money and bonds) is irrelevant, since bonds are redeemed in fiat money at par. Thus, let $W(z, B, s)$ be the value of entering the night market with total (normalized) nominal balances z.

In the day market, consumers and producers exchange money and bonds for goods at (normalized) price p_x. Let x be the individual quantity consumed and κ the individual quantity produced; these quantities are generally different in equilibrium, unless there is an equal measure of consumers and producers. A consumer with starting balances (m, b) has total liquidity $m + \theta b$ to purchase day output. The problem of a consumer is

$$V^c(m, b, B, s) = \max_x \; u(x) + W(m + b - p_x x, B, s)$$

subject to: $p_x x \leq m + \theta b$. The problem of a producer is

$$V^p(m, b, B, s) = \max_\kappa \; -\phi\kappa + W(m + b + p_x\kappa, B, s).$$

Hence, the *ex ante* value of an agent with portfolio (m, b) at the start of the period satisfies $V(m, b, B, s) \equiv \eta V^c(m, b, B, s) + (1 - \eta)V^p(m, b, B, s)$.

At night, the problem of an agent arriving with total nominal balances z is

$$W(z, B, s) = \max_{c,n,m',b'} \; \gamma U(c) - \alpha n + v(g) + \beta E[V(m', b', B', s')|s]$$

subject to: $p_c c + (1 + \mu)(m' + qb') = p_c(1 - \tau)\zeta n + z$.

2.3 Monetary equilibrium

The resource constraints in the day and night equate total consumption to total production in each subperiod. The resource constraint in the day is $\eta x = (1 - \eta)\kappa$. Given the assumptions on preferences, individual consumption at night is the same for all agents, whereas individual labor depends on whether an agent was a consumer or a producer in the day. Hence, the resource constraint at night is given by $c + g = \zeta[\eta n^c + (1 - \eta)n^p]$, where n^c and n^p denote night-labor by agents that were consumers or producers in the day, respectively. As shown in Lagos and Wright (2005), the preference specification also implies that all agents make the same portfolio choice. Market clearing at night implies $m' = 1$ and $b' = B'$.

The literature on optimal government policy with distortionary instruments typically adopts what is known as the *primal approach*, which consists of using the first-order conditions of the agent's problem to substitute prices and policy instruments for allocations in the government budget constraint. Following this approach, the problem of a government with limited commitment can be written in terms of choosing debt and allocations. After some work (see Appendix A), we get the following conditions characterizing prices (p_x, p_c, q) and policy instruments (μ, τ)

in a monetary equilibrium:

$$p_x = \frac{(1+\theta B)}{x} \tag{2}$$

$$p_c = \frac{\gamma U_c(1+\theta B)}{\phi x} \tag{3}$$

$$q = \frac{E[\frac{x'(\eta\theta' u_x' + (1-\eta\theta')\phi)}{1+\theta' B'}|s]}{E[\frac{x'(\eta u_x' + (1-\eta)\phi)}{1+\theta' B'}|s]} \tag{4}$$

$$\mu = \frac{\beta(1+\theta B)}{\phi x} E\left[\frac{x'(\eta u_x' + (1-\eta)\phi)}{(1+\theta' B')}\Big| s\right] - 1 \tag{5}$$

$$\tau = 1 - \frac{\alpha}{\zeta \gamma U_c} \tag{6}$$

Condition (2) is standard in monetary economies: the (normalized) price of the day good p_x equals the total means of payment $1+\theta B$ (i.e., all money plus a fraction θ of bonds) divided by the total quantity traded. Note that variations in θB imply variations in the (measured) velocity of circulation of money. Condition (3) establishes the price of the night good p_c, which depends on the equilibrium quantities traded in the day and night. The relative price between day and night goods, p_x/p_c is pinned down by the first-order condition to the producer's problem: a producer sells goods in the day to save on effort at night and this decision is distorted by labor taxes τ, which as shown by (6) can be expressed as a function of the night-good allocation c.

Condition (4) states the equilibrium price of government bonds as a function of next-period's day-good allocation x' and total means payment $1+\theta' B'$. In essence, the price of a bond reflects its liquidity premium: agents need to be compensated for the fact that bonds are not as liquid as money for purchasing day goods.[11]

Condition (5) states that, for a given expected future day-good allocation (which in equilibrium is a function of debt choice, B' and the exogenous state s'), a higher money growth rate μ implies lower day-good consumption x. In other words, given current debt policy and future monetary policy, the allocation of the day good is a function of *current* monetary policy. Thus, we can interchangeably refer to variations in the day-good allocation, x and variations in current monetary policy, μ.

Condition (6) states the trade-off between the marginal utility of night-good consumption and the marginal disutility of night-labor. This trade-off is distorted by the labor tax: a higher tax rate τ implies lower night-good consumption c. As with monetary policy, we can interchangeably refer to variations in the night-good allocation, c and variations in the tax rate, τ.

Using (2)–(6), we can write the government budget constraint (1) in a monetary equilibrium as a function of allocations and debt,

$$(\gamma U_c - \alpha/\zeta)\, c - (\alpha/\zeta) g - \frac{\phi x(1+B)}{1+\theta B} + \beta E\left[\frac{\phi x'(1+B')}{1+\theta' B'}\Big| s\right] + \beta\eta E[x'(u_x' - \phi)|s] = 0 \tag{7}$$

for all $s \in S$. Condition (7) is also known as an implementability constraint, as it restricts the set of allocations that a government can implement in a monetary equilibrium.

[11] Note that, despite the linearity in the disutility of labor, the real interest rate is not exogenous, and fluctuates with variations in the tax rate. The yield on an illiquid real bond would be $\frac{\gamma U_c}{\beta E[\gamma' U_c'|s]} - 1$; by (6) we can see how this yield depends on taxes today and tomorrow. The real interest rate implied by the liquid bond priced in (4) is a bit more involved and can be obtained from expressions (12) and (13), derived below.

3 Discretionary Policy

3.1 Problem of the government

The government can commit to policy announcements for the current period, but cannot commit to policies implemented in future periods. That is, at the beginning of the period, the current government chooses $\{B', \mu, \tau, g\}$—equivalently, as shown above, implements $\{B', x, c, g\}$—taking as given expected future policy. Policies implemented by the government in the future affect its *current* budget constraint, since future monetary policy affects the current demand for money and bonds. This is reflected by the presence of the future allocation x' in the government budget (implementability) constraint (7). Due to limited commitment, the current government cannot directly control future policy, even though it can affect future policy through its choice of debt, B'. Future allocations depend on the policy expected to be implemented by the government, which in turn, depends on the level of debt it inherits and the exogenous aggregate state of the economy. Let $\mathcal{X}(B, s)$ be the policy that the current government anticipates will be implemented by future governments; this function implies a future day-good allocation, x' for any given future state, (B', s'). The function $\mathcal{X}$ is an equilibrium object, but the current government takes it as given.

From the day resource constraint, we can write production in equilibrium as a function of consumption: $\kappa = \eta x/(1-\eta)$. Thus, an agent's expected flow utility in the day is equal to $\eta[u(x) - x]$. Night output is equal to the consumption of private and public goods and so, we can use the night resource constraint to write expected night labor as $(c+g)/\zeta$. The *ex ante* period utility of an agent can be thus written in terms of the bundle (x, c, g) and the aggregate state of the economy s. Let $\mathcal{U}(x, c, g, s) \equiv \eta[u(x) - \phi x] + \gamma U(c) - (\alpha/\zeta)(c+g) + v(g)$.

As described in the introduction, the analysis presumes the government is in general not benevolent. Following Martin (2015), suppose the government values the utility of its subjects, but may value public expenditure differently: its flow utility is given by $\mathcal{U}(x, c, g, s) + \mathcal{R}(g, \omega)$, where $\mathcal{R}$ is increasing in public expenditure, g and decreasing in the level of government benevolence, $\omega > 0$. Let $\mathcal{R}(g, 1) = 0$, so that $\omega = 1$ indicates the government is benevolent. When $\omega \in (0, 1)$, which is the focus here, the government prefers larger public expenditure than private agents. This expenditure bias may arise from a variety of sources: a desire for empire-building, the spoils of patronage and clientelism, the existence of a self-serving public bureaucracy or the support of the sovereign's lifestyle. Critical to the analysis below is that private agents would prefer the government to spend less, but cannot directly control nor limit this choice. Note that the presence of $\mathcal{U}(x, c, g, s)$ in the flow utility of the government implies it cares about how the policy mix is perceived by private agents. In sum, the government spends too much but does internalize (imperfectly) the implementation costs for private agents.

The following assumption ensures the problem of a non-benevolent government is well-behaved. The requirement is that the problem is strictly concave in government expenditure.

Assumption 1 *Let $\hat{g}(s)$ solve $v_g - \alpha/\zeta + \mathcal{R}_g = 0$ for all $s \in S$ and let $\hat{g} = \max_s \hat{g}(s)$. Then, $v(g)$ and $\mathcal{R}(g, \omega)$ satisfy $v_{gg} + \mathcal{R}_{gg} < 0$ for all $g \in [0, \hat{g}]$ and all $\omega \in (0, 1]$.*

The assumption above allows some flexibility in the functional form of $\mathcal{R}$; when calibrating the model, I will assume it is linear in g.

Let $\Gamma \equiv [\underline{B}, \overline{B}]$] be the set of possible debt levels, where $\underline{B} < \overline{B}$. Taking as given future government policy $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}\}$ the problem of the current government can be written as

$$\max_{B', x, c, g} \; \mathcal{U}(x, c, g, s) + \mathcal{R}(g, \omega) \; + \beta E[\mathcal{V}(B', s')|s]$$

subject to (7) and given a continuation value consistent with expected future policy:

$$\mathcal{V}(B', s') \equiv \mathcal{U}(\mathcal{X}(B', s'), \mathcal{C}(B', s'), \mathcal{G}(B', s'), s') + \mathcal{R}(\mathcal{G}(B', s'), \omega') + \beta E[\mathcal{V}(\mathcal{B}(B', s'), s'')|s'].$$

We now have the necessary elements to define an equilibrium in this economy.

Definition 1 *A Markov-Perfect Monetary Equilibrium (MPME) is a set of functions* $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}, \mathcal{V}\}$: $\Gamma \times S \to \Gamma \times \mathbb{R}^3_+ \times \mathbb{R}$, *such that for all* $B \in \Gamma$ *and all* $s \in S$:

$$\{\mathcal{B}(B, s), \mathcal{X}(B, s), \mathcal{C}(B, s), \mathcal{G}(B, s)\} = \underset{B', x, c, g}{\text{argmax}}\ \mathcal{U}(x, c, g, s) + \mathcal{R}(g, \omega)\ + \beta E[\mathcal{V}(B', s')|s]$$

subject to

$$(\gamma U_c - \alpha/\zeta)\, c - (\alpha/\zeta) g - \frac{\phi x(1+B)}{1+\theta B} + \beta E\left[\frac{\phi x'(1+B')}{1+\theta' B'}\Big| s\right] + \beta\eta E[x'(u'_x - \phi)|s] = 0$$

where $x' \equiv \mathcal{X}(B', s')$ *and*

$$\mathcal{V}(B, s) \equiv \mathcal{U}(\mathcal{X}(B, s), \mathcal{C}(B, s), \mathcal{G}(B, s), s) + \mathcal{R}(\mathcal{G}(B, s), \omega) + \beta E[\mathcal{V}(\mathcal{B}(B, s), s')|s].$$

A Markov-perfect equilibrium is a fixed-point in government policy functions, so that the best response of the current government is follow the same policies it expects to follow in the future, in all states of the economy.

With Lagrange multiplier λ associated with the government budget constraint and multiplier function $\Lambda(B, s)$ associated with future policy $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}\}$, the first-order conditions of the government's problem imply:

$$E\left[\frac{\phi x'(1-\theta')(\lambda - \Lambda')}{(1+\theta' B')^2}\Big| s\right] + \lambda E\left[\mathcal{X}'_B\left\{\eta(u'_x + u'_{xx}x' - \phi) + \frac{\phi(1+B')}{1+\theta' B'}\right\}\Big| s\right] = 0 \quad (8)$$

$$\eta(u_x - \phi) - \frac{\lambda\phi(1+B)}{1+\theta B} = 0 \quad (9)$$

$$\gamma U_c - \alpha/\zeta + \lambda\{\gamma U_c - \alpha/\zeta + \gamma U_{cc} c)\} = 0 \quad (10)$$

$$v_g - \alpha/\zeta + \mathcal{R}_g - \lambda(\alpha/\zeta) = 0 \quad (11)$$

for all $B \in \Gamma$ and all $s \in S$. A *differentiable* MPME is a set of differentiable (a.e.) functions $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}, \Lambda\}$ that solve (7)–(11) for all (B, s). Martin (2011) provides an extended analysis of these conditions and a characterization of the equilibrium, for the case of $\theta = 0$ and without aggregate shocks. Below, I describe the policy trade-offs implied by these conditions.

Conditions (9)–(11) describe the static trade-offs faced by the government when choosing the money growth rate, taxes and public expenditure. Each one of these policy instruments can be used to relax the government budget constraint at the cost of introducing a wedge, which lowers utility for the government (and private agents as well). Importantly, the incentives to inflate are increasing in debt and non-benevolence affects the amount of distortions the government is willing to impose.

Equation (8), known as a Generalized Euler Equation (GEE), describes the intertemporal trade-offs faced by the government when choosing debt. The first term depends on the difference between current and future implementation costs, as reflected by the multiplier on (7), capturing the distortion-smoothing role of debt. From an *ex ante* perspective, this gap would ideally be eliminated in expectation, but this is prevented by the limited commitment friction.

The second term in (8) reflects the time-consistency problem, which consists of how current changes in debt trigger future changes in policy, which in turn, affect the current budget constraint of the government. Choosing a higher debt implies higher inflation tomorrow, which affects the demand for money and bonds today. The impact on the latter is always negative: higher inflation implies higher nominal interest rates; the former depends on how the income and substitution effects determine how the current demand for money is affected by future higher inflation. When income effects dominate, the overall effect of higher debt is to relax the government budget constraint at low level of debt and to tighten it for high levels of debt.

As shown in Martin (2011, 2015), when debt is illiquid, the non-stochastic version of this economy features the property that the steady state of the Markov-perfect equilibrium is constrained-efficient. Thus, endowing the government with commitment at the steady state would not affect the allocation. The result is summarized in the following proposition, generalized here for the case with liquid debt—details are provided in Appendix B.

Proposition 1 *Let $S = \{s^*\}$ and assume initial debt $B^* = \mathcal{B}(B^*, s^*)$. Then, a government with commitment and a government without commitment will both implement the allocation $\{x^*, c^*, g^*\}$ and choose debt level B^* in every period.*

In the absence of aggregate fluctuations, private agents cannot be made better-off at the steady state by endowing the government with more commitment power. The only long-run inefficiency in this economy stems from the political friction, i.e., the misalignment in preferences between private agents and government. Outside the steady state or in the presence of aggregate fluctuations, government policy will exhibit inefficiencies due to both a time-consistency problem and the political friction.

4 Constrained Government Policy

Though private agents cannot dictate the government how much to spend, they may be able to regulate other components of the budget. In order to place constraints on government policy we first need to define some relevant macroeconomic variables: GDP, actual and expected inflation, the nominal interest rate, government expenditure and revenue, primary and total deficits, and debt over GDP.

4.1 Defining macroeconomic variables

Let us start by computing nominal GDP, a variable that is used to scale macroeconomic aggregates. Day and night output are equal to ηx_t and $c_t + g_t$, respectively. Then, nominal output is defined as $Y_t \equiv p_{x,t}\eta x_t + p_{c,t}(c_t + g_t)$. Nominal GDP, like other nominal variables, is normalized by the aggregate money stock.

Next, let us define monetary variables, like prices, inflation and interest rates. Let $\varsigma_{x,t}$ and $\varsigma_{c,t}$ be the day-good and night-good expenditure shares, respectively. That is, $\varsigma_{x,t} \equiv p_{x,t}\eta x_t/Y_t$ and $\varsigma_{c,t} \equiv p_{c,t}(c_t + g_t)/Y_t$. Let $\Upsilon_t \equiv \eta\phi x_t[\gamma_t U_{c,t}(c_t + g_t)]^{-1}$ and so, $\varsigma_{x,t} = (1 + 1/\Upsilon_t)^{-1}$ and $\varsigma_{c,t} = (1+\Upsilon_t)^{-1}$. Fixing expenditure shares to those corresponding to the non-stochastic steady state (B^*, x^*, c^*, g^*), yields ς_x^* and ς_c^*. The price level can then be defined as $P_t \equiv \varsigma_x^* p_{x,t} + \varsigma_c^* p_{c,t}$. Real GDP is then defined as Y_t/P_t.

Let inflation be defined as $\pi_t \equiv P_t(1 + \mu_{t-1})/P_{t-1} - 1$ and expected inflation as

$$\pi_{t+1}^e \equiv \frac{E_t[P_{t+1}](1 + \mu_t)}{P_t} - 1. \quad (12)$$

The nominal interest rate is defined as

$$i_t \equiv \frac{1}{q_t} - 1. \tag{13}$$

Next, consider fiscal variables. Government expenditure (excluding interest payments) in terms of GDP is

$$\upsilon_t \equiv \frac{p_{c,t} g_t}{Y_t}. \tag{14}$$

Revenue over GDP is defined as

$$\rho_t \equiv \frac{p_{c,t} \tau_t (c_t + g_t)}{Y_t}. \tag{15}$$

The primary deficit is the difference between government expenditure before interest payments and tax revenue. The primary deficit over GDP is then defined as:

$$d_t \equiv \frac{p_{c,t}[g_t - \tau_t(c_t + g_t)]}{Y_t}. \tag{16}$$

The total fiscal deficit includes the primary deficit plus interest payments on the debt. The deficit over GDP is defined as:

$$D_t \equiv \frac{p_{c,t}[g_t - \tau_t(c_t + g_t)] + (1+\mu_t)(1-q_t)B_{t+1}}{Y_t}. \tag{17}$$

Debt is measured at the end of the period, as in the data. Thus, debt-over-GDP is defined as $\frac{(1+\mu_t)B_{t+1}}{Y_t}$. Finally, we can also define the growth rate of total (nominal) government liabilities as

$$\ell_t \equiv \frac{(1+\mu_t)(1+B_{t+1})}{1+B_t} - 1 \tag{18}$$

Appendix C derives all these expressions in terms of debt and allocations, which are the ones used as constraints in the government's problem subject to fiscal rules.

4.2 Fiscal rules

Fiscal rules incorporate elements from both Neo-Hobbesian and Pigouvian traditions of public finance.[12] The former advocates making the tax base inefficient to curb the *Leviathan* (the beast, i.e., the government), while the latter is concerned with how to optimally finance the provision of public goods. Fiscal rules are generally intended to discipline government actions, particularly, preventing it from growing too large or setting off on an unsustainable path. At the same time, rules affect how governments are financed and hence, may better align the policy mix with the preferences of the governed.

Fiscal rules can be categorized in broad groups, depending on which type of policy variable they target: expenditure, revenue, budget balance and debt.

Expenditure rules limit spending in level, growth rate or as a percentage of output. Here, I will consider rules that impose a ceiling on (primary) expenditure over GDP: $\upsilon_t \leq \bar{\upsilon}$, where υ_t is given by (14). In Appendix D, I also consider limits on the absolute level of spending.

Revenue rules constrain tax revenue. The specific rule used here states that revenue over GDP cannot exceed a legislated ceiling: $\rho_t \leq \bar{\rho}$, where ρ_t is given by (15). Note that revenue rules are not strictly the same as limits on tax rates. The latter would simply target τ_t which

[12] See Brennan and Buchanan (1977) and Engineer (1990).

by (6) is equivalent to determining night-good consumption, c_t. However, it turns out that the quantitative performance of either type of constraint is very similar—see Appendix D.

Budget balance rules are constraints to the primary or total deficit. Consider ceilings on the primary deficit and the total deficit, both in terms of GDP, which take the form $d_t \leq \bar{d}$, $D_t \leq \bar{D}$, respectively, where d_t and D_t are as defined in (16) and (17). Importantly, budget balance rules do not directly constrain expenditure, only the revenue shortfall. In other words, the governments is free to choose how it will best achieve the required budget balance and may not do so in the way preferred by private agents.

There are two commonly-used types of debt constraints: an upper limit on debt over GDP and a ceiling on the nominal value of outstanding debt. That is, constraints of the form: $(1 + \mu_t)B_{t+1}/Y_t \leq \bar{b}$ and $B_{t+1} \leq \bar{B}$. The former is akin to the Maastricht convergence criteria on debt, while the latter is similar to the debt ceiling imposed by the U.S. Congress on the federal government. Note that even though B is the bond-money ratio, this latter constraint should be interpreted as a limit on the nominal stock of debt.

There is an additional type of debt rule we should consider, which constrains its growth rate rather than its level. We can consider rules that limit the growth of debt, B or of total government liabilities, $1 + B$. On their own, both versions of this rule turn out to yield almost identical welfare implications. However, when combined with a revenue ceiling, as I will consider below, limiting the growth rate of total government liabilities performs significantly better than limiting the growth rate of just debt. Hence, I will focus on limits to the growth rate of total government liabilities: $\ell_t \leq \bar{\ell}$, where ℓ_t is as defined in (18).[13] Note that in a non-stochastic steady state, since the bond-to-money ratio would be constant, a binding liabilities growth limit would also set the inflation rate. It is important to point out that, despite this implication for the long-run, a limit on the growth rate of government liabilities is not equivalent to ceilings on the inflation rate, $\pi^e_{t+1} \leq \bar{\pi}$ or the money growth rate, $\mu_t \leq \bar{\mu}$. This is easy to see by comparing expressions (5), (12) and (18).

Fiscal rules can be imposed on all exogenous states of the world or on select ones. For example, it may be undesirable to restrict government behavior when output is low (say, requiring a surplus during a recession). However, this may be precisely the time when government behavior *ought* to be restricted. I will consider all these possible cases in the analysis below.

4.3 Recursive formulation

Let us now include the policy constraints in the recursive formulation of the government's problem. The indicator function $\mathcal{I}_j$ states whether a constraint of type $j = 1, \ldots, J$ is currently in effect. Hence, the exogenous aggregate state now includes the possibility of policy rules being in effect: $s \equiv \{\gamma, \zeta, \theta, \omega, \mathcal{I}_1, \ldots, \mathcal{I}_J\}$; the state space S is correspondingly augmented. In general, whether a constraint will be in effect or not may depend on current or future states. For example, a policy rule may be implemented with some probability in future periods and remain in effect from the on, or be abandoned with some probability; or a policy rule may be in effect unless there is an "adverse" shock. I will consider several specific cases in the quantitative section of the paper.

Constraints on policy can be written then as

$$\psi_j - \mathcal{I}_j \times \Psi^j(B, B', x, c, g, s; \mathcal{X}) \geq 0 \tag{19}$$

[13]There is also minor technical reason that makes limiting the growth rate of total government liabilities preferable. A (binding) limit on the growth rate of debt, $(1 + \mu_t)B_{t+1} \leq (1 + \bar{\ell})B_t$, imposes a non-stochastic steady state at zero debt, regardless of $\bar{\ell}$. This steady state with zero debt turns out to be stable and so, the economy converges to it. In contrast, a limit on the growth rate of total liabilities allows the steady state to depend nontrivially on the rule.

The function Ψ^j corresponds to each of the constraints described above, given future anticipated policy function $\mathcal{X}(B', s')$, which determines the future day-good allocation x' as a function of the aggregate state. The parameter ψ_j is the j^{th} element of the constraint vector $\psi \equiv \{\bar{v}, \bar{\rho}, \bar{d}, \bar{D}, \bar{b}, \bar{B}, \bar{\ell}\}$ and corresponds to the value by which a particular policy variable is constrained (e.g., a primary deficit ceiling, $\bar{d}$). Specified in this way, all constraints depend on the current policy choice (B', x, c, g), the current state (B, s) and expected future policy choices $\mathcal{X}(B', s')$, for all $B' \in \Gamma$ and all $s' \in S$. However, some constraints depend trivially on some of the arguments. For example, a primary deficit ceiling only depends non-trivially on (x, c, g) and s, while a nominal debt ceiling only depends non-trivially on B'. Note that a liabilities growth limit is the only rule that depends explicitly on the inherited level of debt, B. However, all rules interact with inherited debt through the budget constraint, (7).

The problem of the government can be written similarly to the unconstrained case, with the addition of (19) for all $j = 1, \ldots, J$. Similarly, the definition of a MPME now includes (19) for all $j = 1, \ldots, J$, $B \in \Gamma$ and $s \in S$.

4.4 Static vs dynamic constraints

Policy rules differ in how they restrict government actions. Compare, for example, primary and total deficit ceilings: as we can see from (45) and (46) in Appendix C, both constraints depend on $\{x, c, g, s\}$, but the deficit ceiling also depends on the choice of debt, B' and the expected realization of future allocations, $\mathcal{X}(B', s')$ for all $s' \in S$. Thus, the deficit ceiling is intrinsically dynamic while the primary deficit ceiling is static.

Expenditure, revenue and primary deficit ceilings are the only rules in the set of policy constraints considered here that do not depend on B', either directly or indirectly through future policy $\mathcal{X}$. Why is this important? Lack of dependence on B' implies that the Generalized Euler Equation (8) is left functionally intact after adding constraint (19) to the government's problem. That is, (8) is not altered by the introduction of a primary deficit or revenue ceilings.

This is not the case for any of the other policy constraints. The Generalized Euler Equation (8) determines how the government is trading off distortion smoothing—the first term in (8)—with the time-consistency problem—the second term in (8). If (19) depends non-trivially on B', then the trade-off in (8) will be upset. In other words, the imposition of a policy constraint, though beneficial as a disciplining device, will hinder the government's ability to smooth distortions intertemporally, which may impose a significant welfare cost to agents.

Ceilings on expenditure, revenue and the primary deficit only affect equations (9)–(11). The added term in each condition is the Lagrange multiplier associated with constraint (19) times the marginal change of the constraint with respect to the relevant variable (x, c, or g, respectively). Hence, these type of constraints will alter the way the government views the intratemporal trade-offs in monetary policy, taxation and expenditure, without affecting the dynamic policy trade-offs in (8). Furthermore, static constraints do not introduce a time-consistency problem. As such, a version of Proposition 1 holds with the addition of a primary deficit or revenue ceiling, which implies that the constrained steady state can be solved locally.

5 Quantitative evaluation

In this section, I describe how I will evaluate policy rules quantitatively. I begin by calibrating the economy with a discretionary (unconstrained) government to the postwar U.S. I then describe the method used to solve the model in the absence of shocks—stochastic economies are studied in Section 7. Finally, I show how policy rules are evaluated.

5.1 Calibration

Consider the following functional forms, as in Martin (2015): $u(x) = \frac{x^{1-\sigma}-1}{1-\sigma}$; $U(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$; $v(g) = \ln g$; and $\mathcal{R}(g,\omega) = (\omega^{-1} - 1)g$. The parameter $\omega > 0$ determines the degree of benevolence of the government, where $\omega = 1$ means the government is fully benevolent.

As argued in Section 3, the steady state of the non-stochastic version of the economy with a discretionary government can be solved locally, i.e., without first having to solve globally for the Markov-perfect equilibrium—see Appendix B for the relevant set of equations. This is a common property in this class of models and allows us to solve for the discretionary steady state with high numerical precision. We can therefore search for parameter values that match calibration targets, as described below.

The steady state of the economy with a discretionary government, i.e., unconstrained by policy rules, is calibrated to the post-war, pre-Great Recession U.S., 1955–2008.[14] Government in the model corresponds to the federal government and period length is set to one year. Five of the seven targeted variables in the calibration are taken from the Congressional Budget Office and measured over a fiscal year: debt over GDP, inflation, nominal interest rate, outlays (not including interest payments) over GDP and revenues over GDP. Government debt is defined as debt held by the public, excluding holdings by the Federal Reserve system. Inflation is defined as the annual growth in the GDP deflator. The nominal interest rate corresponds to the implicit interest rate (interest payments divided by debt held by the public)—this figure is similar to the average yield of a one-year Treasury bill. These targets are used to calibrate α, β, σ, η and ϕ. Below, I explain the calibration of θ and ω. Note, however, that all parameters need to be calibrated jointly. Parameters values and calibration targets are presented in Tables 1 and 2, respectively.

Table 1: Benchmark calibration

Parameter	Description	Value
α	night market labor disutility	8.9790
β	discount factor	0.9452
σ	curvature of utility functions	3.7009
η	measure of day market consumers	0.3776
ϕ	day market labor disutility	3.7617
θ	bond liquidity	0.3747
ω	government benevolence	0.3400

Normalized parameters: $\gamma = \zeta = 1$.

The liquidity of government bonds, as measured by θ, is calibrated to match the spread between a (partially) liquid and an illiquid government bond. In the model, an illiquid nominal bond would yield the inflation rate plus the real rate, which in steady state equals $\beta^{-1}(1+\mu)-1$. Thus, the liquidity spread in steady state is $1 + i - \beta^{-1}(1 + \mu)$. In the data, I take the on-the-run/off-the-run spread of 5-year treasury notes, as estimated by Fleming (2003).[15] This spread is 3.33% annual in the data, which matches the average between the benchmark and benevolent economies.

Calibrating the extent of political frictions, as captured by ω, poses a difficult challenge. In principle, one would like to have an estimate of the socially optimal level of government

[14] Although there is a legislated debt ceiling, it has been largely irrelevant for curtailing the average amount of public debt sustained over the calibrated period.

[15] Fleming (2003) reports the spread at various maturities. Five years is roughly the duration of the U.S. debt.

expenditure. Such an estimate is of course hard, if not impossible, to come by. Instead, I use an indirect approach, exploiting the property that policy distortions (and therefore, taxes and inflation) are decreasing in benevolence—see (9)–(11). Specifically, I assume that a benevolent government would set the long-run inflation rate at 2% annual, which corresponds to the explicit target adopted by the Federal Reserve since 2012 (and implicitly for some time before then) and by most inflation-targeting central banks around the world. Thus, the set of calibrated parameters need to hit two economies simultaneously: one targeting the actual U.S. economy in 1955-2008 and another one which shares all the same parameter values, except for $\omega = 1$, and that implements 2% inflation in steady state.

Table 2: Non-stochastic steady state statistics for fully discretionary economies

Variable	Statistic	Benchmark	Benevolent
Targeted			
Debt over GDP	$\frac{B(1+\mu)}{Y}$	0.325	0.319
Inflation rate	π	0.036	0.020
Nominal interest rate	i	0.058	0.048
Liquidity spread	$1 + i - \beta^{-1}(1+\mu)$	0.038	0.031
Revenue over GDP	ρ	0.180	0.152
Expenditure over GDP	$\frac{p_c g}{Y}$	0.180	0.148
Non-targeted			
Nominal debt	B	1.733	1.542
Real interest rate	r	0.021	0.028
Primary deficit over GDP	d	0.000	-0.004
Deficit over GDP	D	0.018	0.001
Potential welfare gains		10.10%	—

Note: "Benchmark" matches the U.S. economy for 1955-2008, as described in the text, and uses the parameterization from Table 1;"Benevolent" sets $\omega = 1$.

Expenditure over GDP in the benevolent economy is 3.2 percentage points lower than in the benchmark economy: 14.8% vs 18.0%. The size of the benevolent government would thus be similar to the actual U.S. federal government from the mid-1950s to the mid-1960s, before its permanent expansion with the introduction of the "Great Society" programs. Note also that the benevolent economy has a zero deficit in steady state, which would be an alternative benchmark for identifying the preferences of private agents that subscribe to the view that the government should "live within its means".

Alternatively, one could look at direct measures of waste and inefficiencies in government spending. A study conducted by the Inter-America Development Bank for Latin America and the Caribbean report that "taking a moderate estimate of inefficiencies in procurement, civil service, and targeted transfers, the total average amount of waste in the region is approximately 4.4 percent of GDP and amounts to about 16 percent of average government spending"—see Izquierdo et al. (2018), §3. Estimates of waste range from 7.2% of GDP for Argentina to 1.8% of GDP for Chile. Interpreting the 3.2 percentage points higher expenditure in the benchmark economy relative to the benevolent economy as due to waste and inefficiencies, the calibration adopted here would place the US in the lower range of these estimates. However, note that under this interpretation, the benchmark economy would waste almost 18% of expenditure, which would place the US in the middle of the pack.

Table 2 presents both targeted and non-targeted moments, as a reference for the exercises conducted below. The targeted moments for the benchmark economy correspond to the calibrated statistics described above. For robustness, I also study two alternative calibrations in Appendix F: one with a bigger government and one with lower inflation. The former assumes a less benevolent government and implies expenditure over GDP rises to 21%, i.e., 3 percentage points higher than in the benchmark economy. The latter redoes the calibration exercise described above, but assuming that inflation is 2% for the U.S. economy, as in more recent times, and that public expenditure by a benevolent government is the same as in the benchmark case.

5.2 Global numerical solution

The next step is to solve globally for the equilibria of the various economies studied here. Let $\Gamma = [\underline{B}, \overline{B}]$ be the debt state space, where $\underline{B} < B^* < \overline{B}$ and B^* is the steady state in the discretionary equilibrium. As argued above and shown in Appendix B, the discretionary steady state can be solved locally. We can typically set $\underline{B} = 0$.[16] Define a grid of N_Γ points over Γ. I set $N_\Gamma = 20$ in most cases.[17] For the cases with a debt over GDP limit and a debt ceiling, I use $N_\Gamma = 100$; these require higher precision in the grid as the steady state will be at, or very close to, the constraint on debt. As explained below, the solution is verified over a finer grid. Since many calculations will be conducted at the discretionary steady state, B^*, it is important that B^* itself is a point in the grid. This will allow for more accurate welfare computations.

Next, guess the functions $\mathcal{B}(B)$, $\mathcal{X}(B)$, $\mathcal{C}(B)$, and $\mathcal{G}(B)$, all evaluated at the N_Γ grid points. I use cubic splines to interpolate between debt grid points and calculate the derivatives of policy functions.

To solve the Markov-perfect equilibrium when the government is discretionary, I use a non-linear equations solver to solve the system given by the non-stochastic versions of equations (7)–(11) (see Appendix B). Condition (11) can be used to solve for the multiplier function $\Lambda(B)$, so that leaves $N_\Gamma \times 4$ equations. The unknowns are the values of the policy functions $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}\}$ at the grid points. In each step of the solver, the corresponding cubic splines that characterize equilibrium functions need to be updated so that the interpolated evaluations of future choices are consistent with each new guess. The precision of the solution using this algorithm is high. For the benchmark economy, the sum of square residuals of the government budget constraint, evaluated at a 1,000 grid points in Γ is in the order of 10^{-10}; the same calculation but performed on the total derivative of the government budget constraint with respect to B (which is exactly zero in theory but was not used in the computations) is in the order of 10^{-7}.

Computing the solution of economies with policy rules is more difficult. Beforehand, we do not know when a policy rule, which is an inequality constraint, will bind. It may be the case that a policy rule binds for all $B \in \Gamma$ or for only a specific region of the state space (or not at all). When policy rules bind only in certain regions, there could be a kink in some policy functions; this could be problematic if the kink is in $\mathcal{X}$, whose derivative shows up in the Generalized Euler Equation—this turns out not to be the case here, as shown and explained in Appendix E.

To solve economies with policy constraints, I first apply a constrained maximization numerical algorithm, using the unconstrained (discretionary) equilibrium as the initial guess. This method is not as precise as using first-order conditions, but gets around the potential problem

[16] The only exceptions I found were for a couple of cases involving a liabilities growth limit; in such cases $\underline{B}$ was lowered appropriately.

[17] For these cases, $N_\Gamma = 10$ works well and is considerably faster. However, I kept the larger gridsize for added precision, particularly in terms of steady state statistics.

of occasionally binding policy rules and shows whether it would be valid to use the Generalized Euler Equation. Except for the case of a debt-over-GDP limit, I next solve the model using the first-order conditions to the (constrained) government's problem to increase the accuracy of the numerical solution, using the solution to the constrained maximization problem as the initial guess. The algorithm is similar to the discretionary case, with the addition of one equation (the policy rule) and a corresponding Lagrange multiplier function. Using two methods for computing equilibria provides an additional source of verification for the numerical solutions.

5.3 Policy rule evaluation

Policy rules are imposed for all debt levels. The optimal value for a constraint is picked by evaluating welfare at the steady state of the non-stochastic fully discretionary economy and includes the full transition to the new steady state.

Welfare is expressed in terms of equivalent compensation, measured in units of night-good consumption. Formally, for each policy constraint Ψ^j and associated constraint parameter ψ_j, $j = \{1, \ldots, J\}$, welfare is measured at each level of debt as the proportion $\Delta^j(B)$ that solves

$$\eta[u(\mathcal{X}(B)) - \phi\mathcal{X}(B)] + U(\mathcal{C}(B)(1+\Delta^j(B,\psi_j))) + v(\mathcal{G}(B)) - \alpha(\mathcal{C}(B)+\mathcal{G}(B)) + \beta V(\mathcal{B}(B)) = \bar{V}^j(B;\psi_j)$$

where $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}\}$ is the fully discretionary non-stochastic Markov-perfect equilibrium, with associated agent's value function $V(B)$, and $\bar{V}^j(B;\psi_j)$ corresponds to the agent's value function in a Markov-perfect equilibrium associated with policy constraint j and constrain parameter ψ_j. Given the assumptions on functional forms, the equivalent compensation has a closed-form solution:

$$\Delta^j(B,\psi_j) = \left\{ \frac{(1-\sigma)[\bar{V}^j(B;\psi_j) - V(B)]}{\mathcal{C}(B)^{1-\sigma}} + 1 \right\}^{1/(1-\sigma)} - 1$$

if $\sigma \neq 1$ and $\Delta^j(B,\psi_j) = \exp\{\bar{V}^j(B;\psi_j) - V(B)\} - 1$ if $\sigma = 1$. As mentioned above, the optimal value ψ_j for constraint j solves

$$\max_{\psi_j} \ \Delta^j(B^*, \psi_j).$$

Recall that the fully discretionary steady state is constrained-efficient, so that welfare gains from imposing policy constraints may come from two sources: mitigating the government's expenditure bias and altering the policy mix. Since we are dealing with second-best outcomes, it is not *a priori* obvious which of the two sources will matter the most, if at all.

As a reference, the last line in Table 2 presents the welfare gains to private agents from making the government fully benevolent, evaluated at the discretionary, non-benevolent steady state.[18] These gains amount to 10.10% of consumption in the benchmark calibration.

6 Fiscal rules in non-stochastic economies

In this section, I study the properties of fiscal rules in the absence of shocks. Importantly, the lessons learned here will generally carry over to the stochastic case. I begin by analyzing revenue, budget balance and debt rules. That is, an institutional environment where the same frictions that give rise to excessive government expenditure make it politically inviable to directly constrain spending. The main lesson is that only a revenue ceiling is effective at curbing

[18] Notably, almost identical gains can be obtained by placing a suitable constraint on government expenditure—see Appendix D. The working assumption here is that it is not feasible (or it is too costly) to improve government benevolence or to impose explicit constraints on expenditure.

government spending, but insufficiently so. Next, I study combinations of revenue ceiling with other fiscal rules, and compare them to an expenditure ceiling. These rules are more effective and beneficial, though there are some notable differences in outcomes.

6.1 Optimal fiscal rules when directly constraining expenditure is not viable

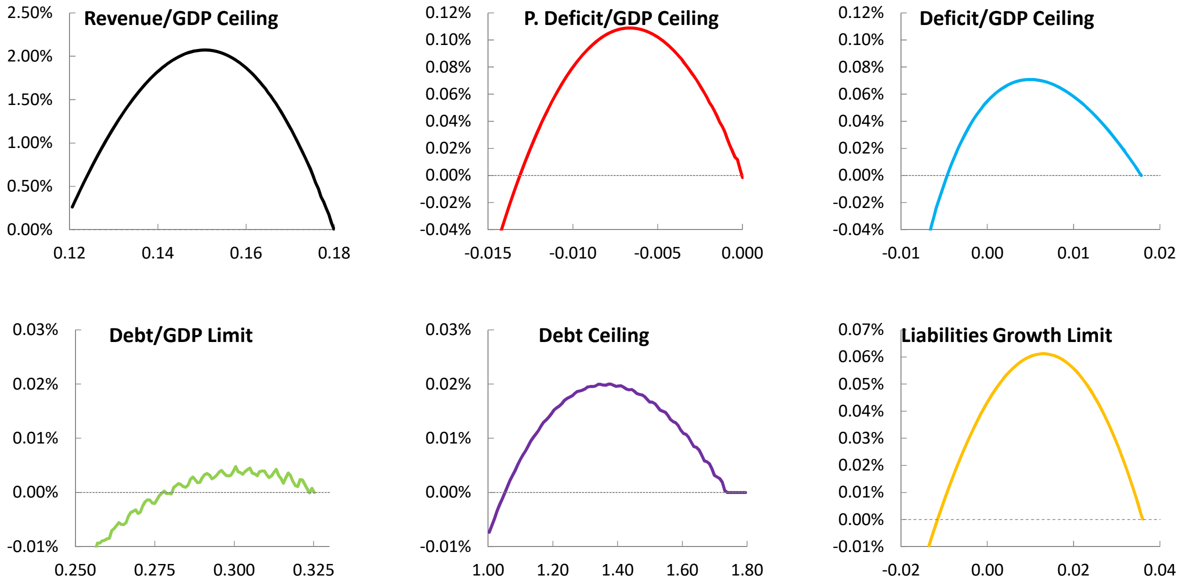
Table 3 presents the effects of revenue, budget balance and debt rules, each evaluated at their corresponding optimal value. There are three sets of information on display. The first set shows the optimal values for each policy constraint. The second set shows the associated welfare gains, measured at B^*; these gains are further decomposed into "steady state" gains, i.e., assuming an immediate jump into the new steady state, and "transition" gains, which measure the complement. The third set shows steady state statistics under each policy constraint. Figure 1 shows the welfare gains, $\Delta^j(B^*, \psi_j)$, for each constraint j, associated with various values for the constraint parameter ψ_j, starting below the optimal value and stopping where the rule would no longer bind (i.e., at the value equal to the discretionary steady state). Finally, Appendix E provides charts with policies, allocations and welfare, as functions of debt, for each of the cases considered here.

Table 3: Optimal fiscal rules and steady state statistics—benchmark calibration

Variable / Constraint	Revenue /GDP ceiling $\bar{\rho}$	P.deficit /GDP ceiling $\bar{d}$	Deficit /GDP ceiling $\bar{D}$	Debt /GDP limit $\bar{b}$	Debt ceiling $\bar{B}$	Liabilities Growth Limit $\bar{\ell}$
Optimal constraint	0.151	−0.007	0.005	0.300	1.380	0.013
Welfare gains	2.07%	0.11%	0.07%	0.00%	0.02%	0.06%
Steady State	1.36%	0.25%	0.71%	0.11%	0.21%	0.93%
Transition	0.71%	−0.15%	−0.64%	−0.11%	−0.19%	−0.87%
Steady state statistics						
Debt over GDP	0.477	0.284	0.171	0.301	0.281	0.120
Inflation rate	0.120	0.010	0.012	0.033	0.031	0.013
Nominal interest rate	0.108	0.042	0.043	0.056	0.055	0.044
Liquidity spread	0.077	0.027	0.028	0.037	0.036	0.028
Revenue over GDP	0.151	0.186	0.182	0.180	0.180	0.180
Expenditure over GDP	0.172	0.180	0.180	0.180	0.180	0.180
Nominal debt	3.091	1.432	0.706	1.530	1.380	0.459
Real interest rate	−0.010	0.031	0.030	0.022	0.023	0.030
Primary deficit over GDP	0.021	−0.007	−0.002	0.000	0.000	0.000
Deficit over GDP	0.067	0.005	0.005	0.016	0.015	0.005

All types of constraints can be effective at increasing private agents' welfare: gains span from a maximum of 2% of consumption for the case of a revenue ceiling to a minimum of barely above zero for the case of a debt over GDP limit. The optimal revenue ceiling is about 15% of GDP, i.e., three percentage points lower than in the unconstrained economy. The next-best constraint, a ceiling on the primary deficit of about half a percent of GDP, yields welfare gains an order of magnitude lower than the optimal constraint on revenue. Debt constraints, either in levels or in proportion to output, turn out to be not very desirable, yielding small welfare

Figure 1: Welfare gains of fiscal rules over full discretion, $\Delta^j(B^*, \psi_j)$



gains; constraining the growth rate of total government liabilities (or, alternatively, the growth rate of debt) yields higher welfare for private agents than limiting the level of debt. Most fiscal rules, when chosen optimally, bind for all levels of debt. The exceptions are the debt over GDP limit and the debt ceiling, which only bind for sufficiently high levels of debt—this is easily seen in the charts of Appendix E.

As argued in Section 4.4, limits on the primary deficit and revenue differ from other constraints, in that they do not interact with the future level of debt; essentially, they do not distort dynamic incentives, i.e., the ability of the government to smooth distortions over time. Unlike other constraints, the costs of primary deficit and revenue ceilings are all along intratemporal margins.

Figure 1 shows that policy rules are still beneficial for large intervals around their optimal value. For example, any revenue ceiling above 12% and below 18% of GDP yields positive welfare gains for private agents. However, constraints can be detrimental when they are set too tight, potentially leading to large welfare losses.

Table 3 also shows the steady state statistics of constrained economies, which can be compared to the benchmark economy (see Table 2). First, only the revenue ceiling manages to curb government spending, and then somewhat modestly: steady state g drops by about 5% or almost one percentage point in terms of GDP. The next effective rule in this regard, the primary deficit ceiling, lowers steady state g by only 0.03%; just 2 basis points when measured in terms of GDP.[19] The superior welfare performance of the revenue ceiling is explained by its effectiveness in lowering spending. About two-thirds of the gain stem from better steady state policy and one-third from gains along the transition to the new steady state. Note, however, that the new steady state with lower revenue features higher debt and higher inflation; this is the way that the revenue-constrained government avoids lowering expenditure too much.

For all constraints other than the revenue ceiling, the welfare gains from imposing policy rules derive entirely from affecting the policy mix and not at all from mitigating the expenditure

[19]Since public expenditure in the model does not vary significantly with debt, these steady state comparisons are a good approximation to what is going on globally.

bias. In all these other cases, steady-state gains are traded-off with transition losses. In contrast to the revenue ceiling, all other rules yield lower steady-state inflation and debt. For example, the primary deficit ceiling forces tax rates to go up (lower c), which allows inflation to go down (higher x); the change in policy mix results in lower steady state debt. Some constraints may lead to dramatic changes in long-run policy. For example, a deficit ceiling of half a percent of output leads to a severe contraction in debt over GDP, about half of the benchmark economy. Limiting the growth rate of government liabilities turns out to perform very similarly to a deficit ceiling.

6.2 Effectiveness and sustainability

Why does constraining revenue work better than budget balance and debt rules? First, consider how the government can respond when revenue is lowered: it can raise current inflation, raise future inflation (by issuing debt) or lower spending. Table 3 and the figures in Appendix E show that the government chooses to do a little bit of each. Inflation however can only go so far in financing deficits before it becomes too costly. Lowering spending is a critical component of the government's response and drives the resulting welfare gains. Second, consider the next-best rule, a primary deficit ceiling. In this case, the government can satisfy the constraint by raising revenue or lowering spending. It chooses the former, which in turn allows it to lower inflation to mitigate the costs of this action. Similarly, lowering spending is not necessary to satisfy the constraints imposed by other policy rules, which makes them ineffective in this regard.

The results derived above provide a useful roadmap for countries wishing to achieve certain policy goals, such as lower inflation or debt. For example, lower long-run debt can be achieved directly by placing a limit on debt over GDP, a debt ceiling or a liabilities growth limit, but it is more beneficial to achieve this goal through budget balance rules.

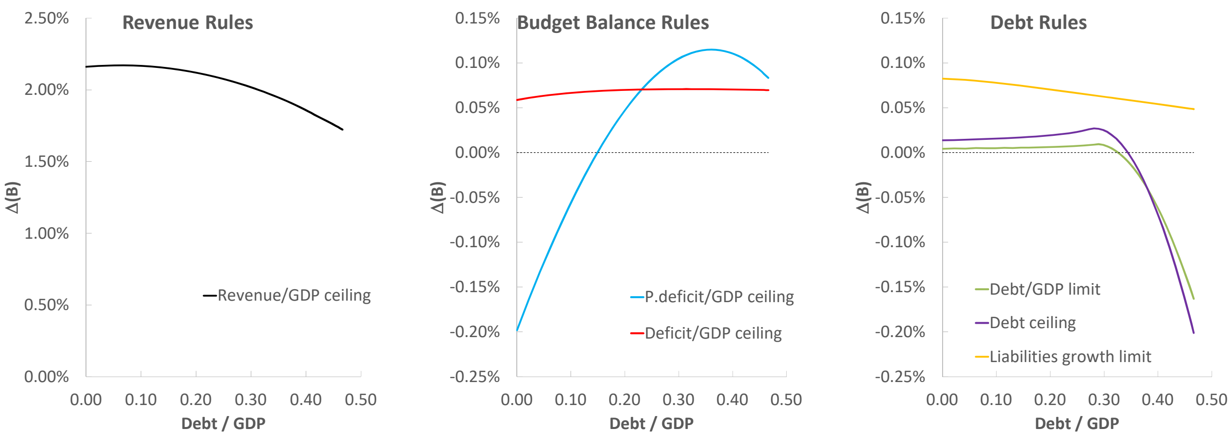
When government spending cannot be directly constrained, a revenue ceiling offers the most effective way to curb it. However, the government response to a revenue rule implies a deterioration of some relevant macroeconomic variables, such as elevated levels of public debt and inflation, which can raise other concerns. Though, in the model, equilibrium levels of debt are always *sustainable* (i.e., the government can always repay its accumulated debt, one way or the other), the level of inflation necessary to sustain them may be interpreted as how sustainable the debt is. Higher inflation means a larger proportion of the debt gets "defaulted" on through inflation. One may also interpret higher inflation as a higher probability of outright default, particularly if the central bank is unwilling to accommodate the larger deficit.

6.3 Timing of reform and austerity programs

The calculations for the optimal values of policy constraints relied on them being implemented at the steady state. A potential concern is that policy rules could be imposed at inappropriate times. What if constraints are first implemented far from steady state? In particular, how does the welfare derived from imposing the optimal values for each policy constraint depend on the level of debt at the moment of introduction? Figure 2 provides an answer to this question, providing welfare gains over full discretionary policy, as a function of initial debt over GDP—see the figures in Appendix E for welfare calculations in terms of the level of debt instead.

The optimal revenue ceiling remains significantly more beneficial than budget balance and debt rules, at all levels of initial debt. Gains increase for lower debt levels, but are still quite sizable at high initial debt levels. As such, a revenue ceiling in not only the most effective among these constraints, but also does not require that the imposition of the rule be implemented close to the steady state.

Figure 2: Welfare gains of optimal fiscal rules by initial debt level



The optimal primary deficit ceiling implies fairly consistent welfare gains when initial debt is high enough. However, when initial debt is low, a cap on the primary deficit can lead to large welfare losses as it severely limits debt accumulation and thus, impinges on the ability of the government to optimally push distortions into the future. On the other hand, the optimal deficit ceiling offers consistent welfare gains for all levels of debt. The difference stems from the fact that at low levels of debt, the constrained government can now run a primary deficit, since the interest paid on debt is low. Hence, a deficit ceiling, as opposed to a primary deficit ceiling, might be a better idea for governments with low initial debt.

In contrast to revenue and budget balance rules, both optimal debt-level constraints can lead to substantial welfare losses when initial debt is high. The reason for this is simple: the debt ceiling forces a sudden adjustment of debt, which goes against the desirability to smooth distortions. This result suggests that it is a bad idea to impose debt limits after events that required deficit-financing (e.g., a recession). Limiting the growth rate of government liabilities is a better alternative; welfare gains are flatter in terms of debt and remain positive even for high initial levels of debt. Notably, this result would still obtain if we had limited the growth rate of debt instead of all liabilities.

Austerity programs, such as those implemented by several European countries in recent times, are designed to reimpose discipline on governments, often with the aim of bringing the debt burden to more "sustainable" levels. We can use the results derived above to interpret the desirability of different austerity measures. Revenue, budget balance and liabilities growth rules are beneficial when initial debt is (much) higher than the steady state and their imposition would be preferred to letting the economy slowly converge back to normal. The analysis suggests that targeting revenue is far more effective than targeting the deficit or the growth rate of government liabilities. Note that, in contrast to common practice, the prescription is not to raise revenue to generate a surplus and thus lower debt, but rather, to lower revenue to reduce expenditure, i.e., *starve the beast*.

6.4 Optimal effective fiscal rules

As we have seen, revenue ceilings vastly outperform balanced budget and debt rules. However, revenue ceilings have unappealing macroeconomic consequences: a substantial increase in inflation and debt. And though their implied welfare consequences dominate those of other rules, there is still a substantial margin for improvement. I will now show that we can address these concerns by coupling a revenue ceiling with another fiscal rule. Since combining fiscal rules severely limits government actions and hence, more effectively mitigates political frictions, I will directly compare these to an expenditure ceiling.

As stated, the problem with revenue ceilings is that they induce a rise in debt and inflation, and allow governments to keep public spending higher than what private agents would prefer. We could thus combine a revenue ceiling with a budget balance or a debt rule. More specifically, let us consider adding a primary deficit ceiling or a liabilities growth limit. In both cases, set the additional constraint to prevent the government from exceeding the corresponding pre-reform steady state value and then, search for the optimal revenue over GDP ceiling. For the benchmark calibration, this means setting a non-negative primary surplus requirement or limiting the growth rate of liabilities up to 3.6% annual. These combinations of fiscal rules are then compared to an expenditure over GDP ceiling, which addresses directly the political friction. Table 4 shows the results for the benchmark economy, Appendix E provides policies, allocations and welfare charts, and Appendix F presents results for alternative calibrations.

Table 4: Revenue ceiling plus budget balance or debt rules vs expenditure ceiling

Variable	Revenue/GDP ceiling plus P.deficit/GDP ceiling	Revenue/GDP ceiling plus Liabilities growth limit	Expenditure/GDP ceiling
Revenue/GDP ceiling	0.148	0.142	—
P.deficit/GDP ceiling	0.000	—	—
Liabilities growth limit	—	0.036	—
Expenditure/GDP ceiling	—	—	0.148
Welfare gains	10.01%	8.40%	10.06%
Steady State	10.01%	11.38%	10.11%
Transition	0.00%	−2.98%	−0.05%
Steady state statistics			
Debt over GDP	0.347	0.031	0.337
Inflation rate	0.036	0.036	0.030
Nominal interest rate	0.058	0.058	0.054
Liquidity spread	0.038	0.038	0.035
Revenue over GDP	0.148	0.142	0.150
Expenditure over GDP	0.148	0.153	0.148
Nominal debt	1.733	0.096	1.660
Real interest rate	0.021	0.021	0.024
Primary deficit over GDP	0.000	0.010	−0.002
Deficit over GDP	0.019	0.012	0.016

Note: When combining rules, the revenue ceiling is chosen optimally, while the primary deficit ceiling or the liabilities growth limit are set equal to their respective discretionary steady-state (pre-reform) values.

The optimal revenue ceiling is slightly stricter than before, but welfare gains are significantly higher. The optimal revenue ceiling on its own yields welfare gains equal to 2.07% of consumption. The combined revenue and primary deficit ceilings imply welfare gains equal to 10.01% of consumption, while the combined revenue and liabilities growth limit imply welfare gains equal to 8.40% of consumption.

Macroeconomic performance is improved as well. In the case of a combined revenue and primary deficit ceilings, there is virtually no transition. Government expenditure immediately falls to its long-run value when the rules are imposed; output falls accordingly and hence, debt over GDP increases slightly. Effectively, the ceiling on the primary deficit (as it turns out, a balanced budget requirement) forces the government to comply with the revenue ceiling by lowering expenditure accordingly. Though the new steady state does not look like the benevolent economy (e.g., debt and inflation are higher), the welfare gains are nearly identical to the potential achievable gains (see Table 2); this is due to the fact that expenditure immediately falls to a value very close to the benevolent level. Note also that the welfare effects of the transition are nearly zero.

By design, the liabilities growth limit imposes a steady-state inflation identical to the pre-reform economy. However, along the transition, inflation is temporarily higher. Debt is virtually eliminated and expenditure drops to just above 15% of GDP. Welfare gains are close to potential, but not as large as in the case of the addition of a primary deficit ceiling. Relative to only being subjected to a revenue ceiling, the government now cannot resort to permanently raising inflation (which would involve permanently increasing the growth rate of its liabilities) and thus, is forced to lower expenditure even more to satisfy the budget constraint. Thus, though the liabilities growth limit proved to be not very effective on its own, it is a powerful tool to correct the undesirable consequences of a revenue ceiling and significantly improve its welfare implications.

The combinations of fiscal rules analyzed above result in austerity programs that work. Public spending is substantially reduced, without altering long-run inflation and yielding significant welfare gains. In both cases, the constraints are binding at all levels of debt, so that imposing them as strict rules rather than inequalities would yield identical results. The combined revenue and primary deficit ceilings appears more appealing: welfare gains are higher and transitions are trivial. In contrast, the combined revenue ceiling and liabilities growth limit implies temporary, higher inflation and the gradual, virtual elimination of public debt.[20]

The last column on Table 4 shows the impact of an optimal ceiling on expenditure over GDP. For the benchmark calibration, this ceiling is 14.8%, which is equal to the steady state policy of a benevolent government. However, debt and inflation are slightly larger, while revenue is slightly lower. Welfare gains, at 10.06% of consumption, are the highest of all fiscal rules considered here, though still not quite up to their potential (10.10% as shown in Table 2). All these results are not surprising, as an expenditure over GDP ceiling is the most direct way to address the government's excessive spending.[21] Finally, note that, in contrast to the combination of revenue and primary deficit ceilings, the expenditure ceiling implies a small loss due to the transition.

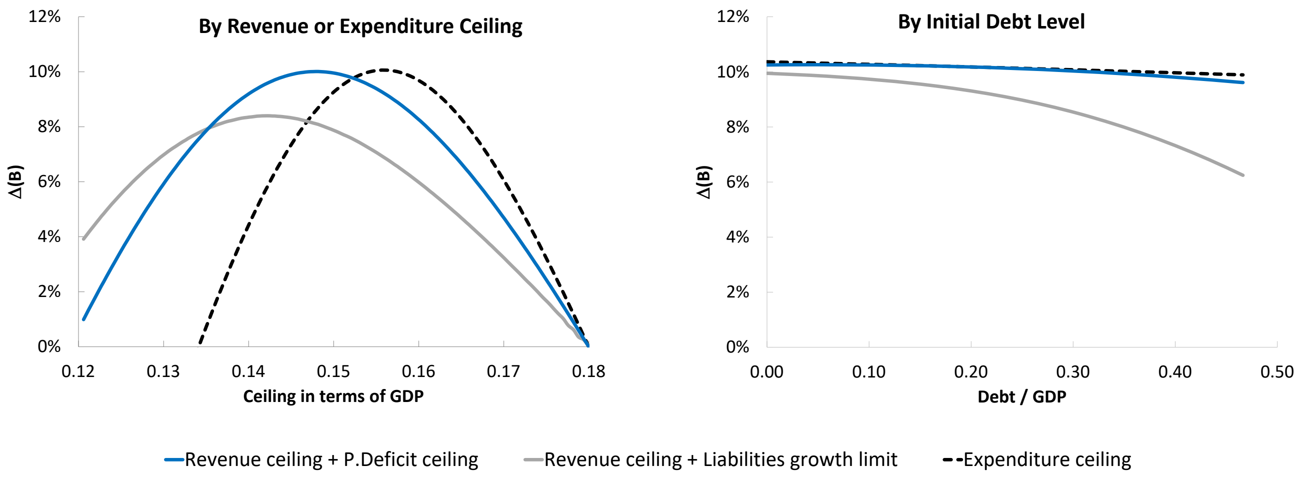
The main difference between a government constrained by a fiscal rule and a benevolent government stems from the fact that fiscal rules are set to be constant over time and thus, imply a different tradeoff between short- and long-run. Relative to a government subject to the optimal expenditure over GDP ceiling, a government that is reformed to become benevolent, trades-off a larger transition cost for higher steady state gains, which result in higher overall gains. Though the differences in welfare are insignificant the resulting long-run policies are different, as described above.

Figure 3 complements the analysis above by showing welfare gains by revenue or expenditure ceiling and initial debt level. The two panels are the analogs of Figures 1 and 2. Welfare gains over full discretion when rules are combined are quite seizable, even when the revenue ceiling is not very strict or when initial debt is far from the steady state. In contrast, though the optimal expenditure over GDP ceiling is the most beneficial fiscal rule, it can more quickly

[20] I omit including charts with transition paths to save space, but they are available upon request.

[21] Appendix D shows that an expenditure ceiling performs worse than an expenditure over GDP ceiling.

Figure 3: Welfare gains over full discretion—Benchmark calibration



become detrimental when applied too strictly. These results suggest a trade-off between pure economic gains and political feasibility: milder, but easier to implement reforms can still yield highly beneficial outcomes.

6.5 Expected reforms

Institutional reforms are not typically implemented unannounced but instead, are worked out and planned in advance. To understand the effects of expected reform, suppose that, under discretion in the benchmark economy, there is a 10% probability each period that a given policy rule is implemented. After the reform is enacted, the policy rule remains in effect forever. In other words, agents expect a specific (and permanent) policy rule to be introduced in about 10 years. Table 5 summarizes the results of this exercise, labeled "Expected", assuming that the economy starts at the discretionary steady state. The results thus capture the welfare gains for private agents when the reform is announced.

It is immediately apparent that the values for the optimal constraints do not vary significantly between the "benchmark" and "expected" scenarios. That is, optimal policy rules do not much depend on whether they are imposed now or at some point in the future. Welfare gains do vary as the potential gains contract to about a third, from 10% to 3.5% of consumption. The benefits of fiscal rules are significantly diluted in all cases since, in expectation, the economy remains under discretion for 10 more years. Hence, fiscal rules should be implemented as soon as possible.

7 Rules vs discretion in stochastic economies

The lessons derived above apply to economies without aggregate fluctuations. In this section, I will study the role of constraints on discretionary governments when the economy is subjected to a variety of (expected) aggregate shocks. Notably, the prescriptions from the non-stochastic case carry over to stochastic economies. However, studying aggregate fluctuations also allows us to derive new lessons; e.g., whether certain constraints should be suspended occasionally. I will thus focus these exercises on infrequent, big shocks, i.e., those when the temptation to abandon rules and apply discretion are arguably the greatest.

Table 5: Optimal fiscal rules—The effects of anticipation

Constraint	Benchmark		Expected	
	Optimal Constraint	Welfare Gain	Optimal Constraint	Welfare Gain
Revenue/GDP ceiling	0.151	2.07%	0.147	0.84%
P.deficit/GDP ceiling	−0.007	0.11%	−0.006	0.03%
Deficit/GDP ceiling	0.005	0.07%	0.007	0.03%
Debt/GDP limit	0.301	0.00%	0.248	0.01%
Debt ceiling	1.380	0.02%	1.380	0.01%
Liabilities growth limit	0.013	0.06%	0.014	0.03%
Revenue/GDP ceiling plus				
P.deficit/GDP ceiling	0.148	10.01%	0.148	3.49%
Liabilities growth limit	0.142	8.40%	0.137	3.33%
Expenditure/GDP ceiling	0.148	10.06%	0.148	3.49%

Note: "Benchmark" assumes the imposition of policy rules is unanticipated. "Expected" assumes policy rules are introduced with a 10% probability each period and remain in effect once enacted. When combining fiscal rules, the revenue ceiling is chosen optimally; the primary deficit ceiling and the liabilities growth limit are set at their pre-reform values, zero and 3.6% annual, respectively.

7.1 Parameterization of stochastic economies

The exogenous state of the economy is given by the values of parameters $\{\gamma, \zeta, \theta, \omega\}$. To keep the analysis as transparent as possible and draw useful lessons, I consider economies with one type of shock at a time. Each economy has three exogenous states, $S = \{s_1, s_2, s_3\}$. Let ϖ_{ij} be the probability of going from state s_i today to state s_j tomorrow. I will interpret s_2 as "normal" times, similar to where the economy lies in the non-stochastic version of the economy. The state s_1 corresponds to "bad" times; s_3, or "good" times, is included for symmetry and so that the stochastic economy fluctuates around the calibrated non-stochastic steady state. The label "bad" refers to states of the world that feature what are generally deemed undesirable macroeconomic outcomes: low aggregate demand, high public expenditure, low average productivity and low real interest rate.

The transition matrix is characterized by two values ϖ and ϖ^* such that: $\varpi_{1,1} = \varpi_{33} = \varpi$; $\varpi_{1,2} = \varpi_{3,1} = 1 - \varpi$; $\varpi_{13} = \varpi_{3,1} = 0$; $\varpi_{22} = \varpi^*$; and $\varpi_{2,1} = \varpi_{2,3} = (1 - \varpi^*)/2$. In other words, ϖ^* is the probability of remaining in the normal state of the world, with an equal chance of transitioning to bad times (s_1) or good times (s_3). During bad (good) times there is a chance $1 - \varpi$ of transitioning back to normal times and it is not possible to immediately transition to the good (bad) state.

For the numerical simulations, I will assume $\varpi^* = 0.98$ and $\varpi = 0.90$. That is, normal times last on average 50 years and bad (good) times have an expected duration of 10 years. This parameterization is meant to capture events such as protracted and deep recessions (γ), productivity slowdowns (ζ), financial crises (θ) and wars (ω).[22] That is, infrequent but painful events that strain the will to maintain rules and instead favor the adoption of more politically

[22]Though ω stands for the degree of non-benevolence of the government, a smaller ω implies a higher expenditure that is not enjoyed as much by private agents. In this sense, a temporary decrease in ω can be interpreted as a war, though the interpretation can be more general than that.

Table 6: Stochastic economy parameterization

Economy	s_1	s_2	s_3
Demand shock	$\gamma(1-\varrho_\gamma)$	γ	$\gamma(1+\varrho_\gamma)$
Productivity shock	$\zeta(1-\varrho_\zeta)$	ζ	$\zeta(1+\varrho_\zeta)$
Liquidity shock	$\theta(1+\varrho_\theta)$	θ	$\theta(1-\varrho_\theta)$
Expenditure shock	$\omega(1-\varrho_\omega)$	ω	$\omega(1+\varrho_\omega)$

$\varrho_\gamma = 0.40$	$\varrho_\zeta = 0.15$	$\varrho_\theta = 0.20$	$\varrho_\omega = 0.30$

expedient (discretionary) policies. Such events are a good laboratories for testing whether it is a good idea to temporally suspend normally benign rules. I will also consider more frequent abnormal times, to verify the robustness of the results. For each economy, the corresponding parameter in states s_1 and s_3 is a multiple of the parameter in state s_2, which is equal to the calibrated parameter from Table 1. The parameterization is shown in Table 6.

For each type of shock and each type of constraint, I evaluate four scenarios: (i) constraints apply to all states of the world; (ii) constraints are suspended in the bad state s_1, and so only imposed in states s_2 and s_3; (iii) constraints are only imposed during normal times, i.e., state s_2; and (iv) constraints are suspended in the good state s_3, and so only imposed in states s_1 and s_2. For each case, the optimal constraints are calculated.

In all cases, welfare is evaluated as the equivalent compensation, in terms of night consumption, at the initial state (B^*, s_2), relative to the discretionary outcome. *Welfare gains over full discretion* are defined as the difference between welfare in a particular stochastic constrained case and the fully discretionary stochastic equilibrium.

7.2 Optimal policy constraints for demand shocks

As a benchmark case, consider an economy subjected to fluctuations in aggregate demand, i.e., with shocks to γ. To maintain focus, I will study this case exhaustively and afterwards, verify that the main results obtained for demand shocks also apply to other types of shocks.

An adverse demand shock leads to a drop in output which implies a reduction in revenue. When the government is fully discretionary, it responds by running a primary deficit while output is below normal. This implies debt accumulation, which in turn implies an increase in inflation to partially pay for it. Inflation and the nominal interest rate remain elevated after output returns to normal in order to smoothly bring back debt to pre-shock levels. In contrast, the real rate drops on impact and stays low for a while after the bad shock ends.

Table 7 summarizes the welfare effects of imposing constraints on policy in an economy facing demand shocks. The four right-most columns show the welfare effects of imposing, respectively, policy constraints: (i) always; (ii) in normal and good times (suspended in bad times); (iii) in normal times only; and (iv) in bad and normal times (suspended in good times). The best case is shown in bold. For each type of policy constraint, the column labeled "optimal value" shows the value that corresponds to the best case (the best values for the remaining cases are omitted to simplify exposition but can be seen on Figure 4). Results are shown for all types of fiscal rules considered so far: the first set includes revenue, budged balance and debt/liabilities rules; the second, combines a revenue ceiling with either a primary deficit ceiling or a liabilities growth limit; and finally, an expenditure ceiling. When combining fiscal rules, I proceed as in the non-stochastic case: search for the optimal revenue ceiling assuming either that the government cannot run a primary deficit or that government liabilities are limited to grow at most at the non-stochastic steady state inflation rate, 3.6% annual.

Table 7: Welfare gains over full discretion—demand shocks

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Revenue/GDP ceiling	0.151	**1.98**%	1.80%	1.61%	1.79%
P.Deficit/GDP ceiling	−0.006	**0.11**%	0.09%	0.08%	0.09%
Deficit/GDP ceiling	0.005	**0.07**%	0.07%	0.06%	0.06%
Debt/GPD limit	0.301	0.00%	0.00%	**0.01**%	0.01%
Debt ceiling	1.357	0.02%	0.02%	0.02%	**0.02**%
Liabilities growth limit	0.013	**0.07**%	0.07%	0.07%	0.07%
Revenue/GDP ceiling plus					
P.deficit/GDP ceiling	0.148	**9.77**%	9.27%	8.68%	9.18%
Liabilities growth limit	0.142	**8.21**%	7.71%	7.25%	7.75%
Expenditure/GDP ceiling	0.148	**9.82**%	9.32%	8.74%	9.24%

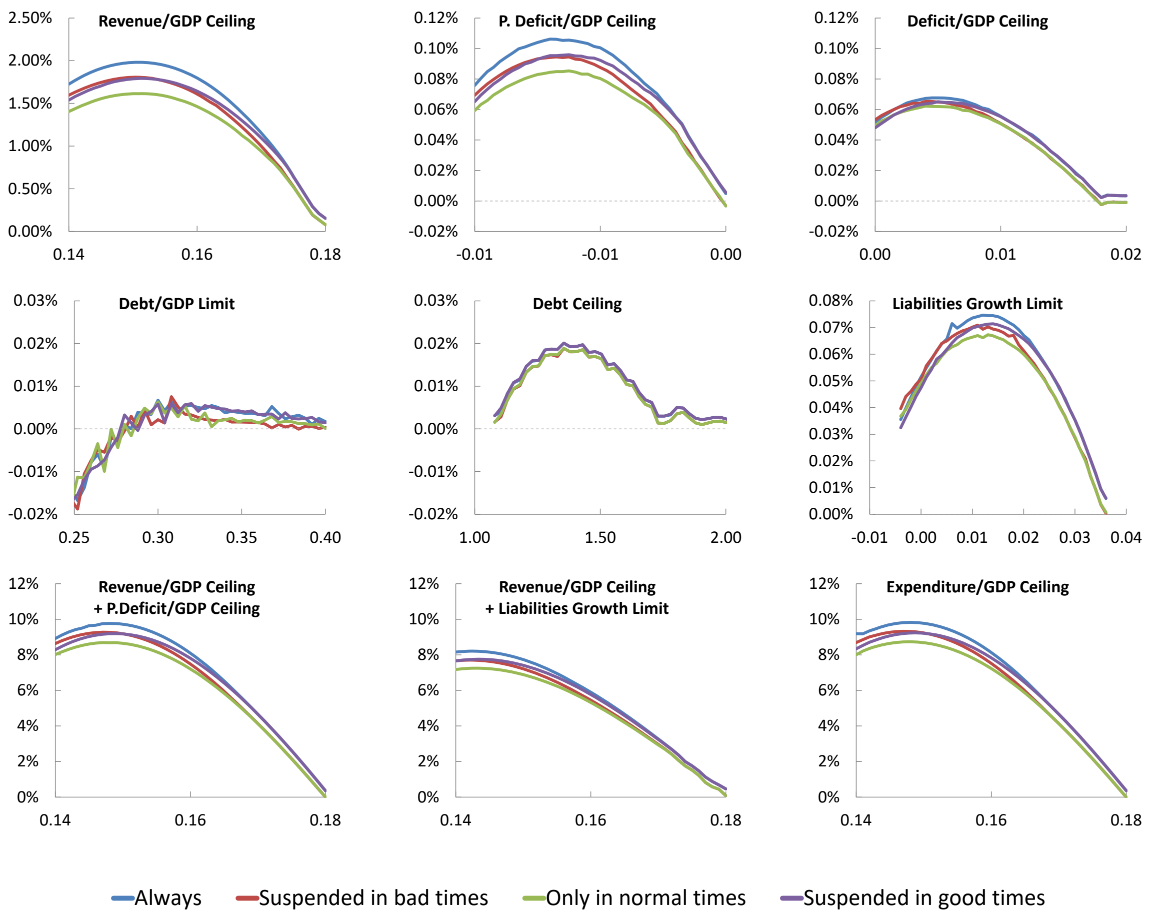
Note: For each type of policy constraint, "optimal value" corresponds to the best scenario (bolded). When combining fiscal rules, the revenue ceiling is chosen optimally; the primary deficit ceiling and the liabilities growth limit are set at their pre-reform values, zero and 3.6% *annual respectively.*

There are several important observations coming out of Table 7 and Figure 4. First, both the optimal values of rules and the welfare benefits of imposing them at all times are very close to those of the non-stochastic economy—see Tables 3 and 4. In part, these results may be due to the low recurrence of shocks. However, the shocks are assumed to be large and persistent; it does not follow *a priori* that infrequent shocks would matter so little for the optimal institutional prescription, both qualitatively and quantitatively. Below, I show that more frequent shocks lower welfare gains, but not by much.

Second, the best prescription is to either directly constrain expenditure or combine a revenue ceiling with another fiscal rule; furthermore, these rules should never be suspended. The optimal expenditure over GDP ceiling is 14.8% yielding welfare gains of about 9.82% of consumption relative to the discretionary equilibrium. When combining fiscal rules, we get the following: if the government cannot run a primary deficit, then the optimal revenue ceiling is 14.8% of GDP, which yields welfare gains of 9.77% of consumption; if the liabilities growth rate is capped at 3.6% annual, then it is optimal to place a revenue ceiling of 14.2% of GDP, which implies welfare gains of 8.21% of consumption. Revenue, budget balance and debt rules are much less beneficial. Again, placing an upper limit on revenue improves welfare the most among this group. The optimal value is to always have a cap on revenue equal to 15.1% of GDP, which implies a welfare gain of 1.98% of consumption.

Third, most fiscal rules are best when they are imposed all the time. Debt rules are the exception, and then, only by a very small margin. Overall, fiscal rules do not significantly hinder the government's ability to smooth out distortions intertemporally since it can still employ monetary policy for that purpose. For all types of constraints, most of the welfare gains come from imposing constraints in normal times and suspending constraints during abnormal times (both bad and good) implies only small differences in welfare, sometimes positive other times negative. This suggests that welfare gains stem primordially from the reduction in government size and change in the long-run policy mix accomplished with the imposition of constraints, and

Figure 4: Welfare gains over full discretion



not from inefficiencies due to how discretionary governments respond to shocks. In this case, trend considerations trump cyclical ones.

Figure 4 expands on the results summarized in Table 7. For each case, the figure plots the welfare gains associated with imposing a particular policy constraint at specific times. One property that pops up immediately is that, for each type of constraint, the optimal value is similar whether we allow the constraint to be sometimes suspended or not. As mentioned above, the welfare changes of temporarily suspending a constraint is minor relative to the overall welfare gains of imposing them in the first place. Both these results are significant for implementation, as there may be other reasons (say, political) for wanting to suspend constraints on government actions at certain times. Note, however, that these conclusions rely on the fact that constraints are to be reimposed when normal times come back.

Is it costly to set the wrong value for a constraint? As Figure 4 illustrates, the answer is typically no. Revenue, expenditure, budget balance (deficit) rules and liabilities growth limits are beneficial for a significant range around the optimum, so getting the exact value for the constraint right is not critical, limiting the costs of improper implementation. Debt constraints are good as long as they are not too tight, since they interact with the ability of the government to smooth distortions.

Consider increasing the frequency of abnormal times or, equivalently, reducing the duration of normal times. Let $\varpi^* = \varpi = 0.9$; that is, all states now have a duration of 10 years. Table 8 present the results. As we can see, the results obtained for the benchmark case still apply.

Even the optimal values for constraint are very close. The only significant difference is a slight decrease in welfare gains. Again, this suggests that most of the welfare gains from fiscal rules arise from constraining government spending.

Table 8: Welfare gains over full discretion when abnormal times are frequent—demand shocks

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Revenue/GDP ceiling	0.151	**1.94%**	1.37%	0.84%	1.34%
P.Deficit/GDP ceiling	−0.007	**0.10%**	0.06%	0.04%	0.06%
Deficit/GDP ceiling	0.005	**0.06%**	0.05%	0.04%	0.05%
Debt/GDP limit	0.301	0.01%	0.01%	0.01%	**0.01%**
Debt ceiling	1.361	**0.02%**	0.02%	0.02%	0.02%
Liabilities growth limit	0.013	**0.07%**	0.05%	0.04%	0.06%
Revenue/GDP ceiling plus					
P.deficit/GDP ceiling	0.148	**9.19%**	7.53%	5.72%	7.37%
Liabilities growth limit	0.143	**7.82%**	6.19%	4.68%	6.21%
Expenditure/GDP ceiling	0.149	**9.26%**	7.58%	5.73%	7.40%

Note: For each type of policy constraint, "optimal value" corresponds to the best scenario (bolded). When combining fiscal rules, the revenue ceiling is chosen optimally; the primary deficit ceiling and the liabilities growth limit are set at their pre-reform values, zero and 3.6% *annual, respectively.*

7.3 Productivity, liquidity and expenditure shocks

We now verify that the main results derived for aggregate demand shocks also apply to other types of shocks. Tables 9, 10 and 11 summarize the welfare effects of imposing constraints on policy in economies facing productivity, liquidity and government expenditure shocks, respectively.

Although each case presents its own idiosyncracies, the similarities across economies are notable. For each type of shock the best prescription remains either an expenditure ceiling or combining a revenue ceiling with a non-negative primary surplus. A close second is to combine a revenue ceiling with a limit on the growth of government liabilities. For the remaining set of fiscal rules, only the revenue ceiling on its own carries a significant welfare gain, though much lower than the best rules. In most cases, it is best to never suspend a fiscal rule. Again, even if the constraint is imposed only during normal times, due to the distortion-smoothing motive, it is still disciplining government behavior during abnormal times. Except for the case with expenditure shocks, the welfare loss of suspending fiscal rules during abnormal times (good, bad or both) is very small. The exception arises (except for debt rules) since spending shocks stem from variations in government benevolence; thus, it becomes important to constrain the government during bad times.

8 Concluding remarks

In this paper, I have evaluated the merits of imposing fiscal rules when society is faced with a government that spends too much. Naturally, imposing a ceiling on expenditure over GDP is best way to curb excessive spending as it directly addresses the source of the inefficiency.

Table 9: Welfare gains over full discretion—productivity shocks

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Revenue/GDP ceiling	0.151	**2.01**%	1.84%	1.62%	1.77%
P.Deficit/GDP ceiling	−0.007	**0.11**%	0.10%	0.08%	0.09%
Deficit/GDP ceiling	0.005	**0.07**%	0.07%	0.06%	0.06%
Debt/GDP limit	0.300	0.01%	0.01%	**0.01**%	0.01%
Debt ceiling	1.358	**0.02**%	0.02%	0.02%	0.02%
Liabilities growth limit	0.013	**0.08**%	0.08%	0.07%	0.07%
Revenue/GDP ceiling plus					
P.deficit/GDP ceiling	0.148	**9.91**%	9.52%	8.70%	9.06%
Liabilities growth limit	0.142	**8.33**%	8.05%	7.25%	7.53%
Expenditure/GDP ceiling	0.148	**9.97**%	9.58%	8.74%	9.13%

Note: For each type of policy constraint, "optimal value" corresponds to the best scenario (bolded). When combining fiscal rules, the revenue ceiling is chosen optimally; the primary deficit ceiling and the liabilities growth limit are set at their pre-reform values, zero and 3.6% *annual, respectively.*

Table 10: Welfare gains over full discretion—liquidity shocks

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Revenue/GDP ceiling	0.151	**2.01**%	1.84%	1.60%	1.77%
P.Deficit/GDP ceiling	−0.006	**0.10**%	0.10%	0.09%	0.09%
Deficit/GDP ceiling	0.005	**0.07**%	0.07%	0.06%	0.06%
Debt/GPD limit	0.301	**0.00**%	0.00%	0.00%	0.00%
Debt ceiling	1.354	**0.02**%	0.02%	0.02%	0.02%
Liabilities growth limit	0.013	**0.08**%	0.07%	0.07%	0.07%
Revenue/GDP ceiling plus					
P.deficit/GDP ceiling	0.148	**9.96**%	9.33%	8.70%	9.35%
Liabilities growth limit	0.142	**8.37**%	7.79%	7.25%	7.82%
Expenditure/GDP ceiling	0.148	**10.06**%	9.39%	8.74%	9.39%

Note: For each type of policy constraint, "optimal value" corresponds to the best scenario (bolded). When combining fiscal rules, the revenue ceiling is chosen optimally; the primary deficit ceiling and the liabilities growth limit are set at their pre-reform values, zero and 3.6% *annual respectively.*

However, note that the resulting allocation features higher debt and inflation than a benevolent economy. Countries do not typically constrain the size of government directly; in fact, expenditure rules focus on the growth rate of expenditure rather than its level. This is not surprising, as the sources of excessive spending (e.g., empire building, patronage, etc) would also provide obstacles to the political approval of such limits.

So, what can countries do when directly curbing spending is not a politically viable option? Among other types of fiscal rules, a revenue ceiling is the only way to effectively induce a

Table 11: Welfare gains over full discretion—government spending shocks

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Revenue/GDP ceiling	0.151	**2.28%**	1.76%	1.64%	2.14%
P.Deficit/GDP ceiling	−0.007	**0.14%**	0.08%	0.08%	0.13%
Deficit/GDP ceiling	0.004	**0.09%**	0.06%	0.06%	**0.09%**
Debt/GPD limit	0.301	0.01%	0.01%	**0.01%**	0.01%
Debt ceiling	1.355	**0.02%**	0.02%	0.02%	0.02%
Liabilities growth limit	0.012	**0.10%**	0.06%	0.06%	0.10%
Revenue/GDP ceiling plus					
P.deficit/GDP ceiling	0.148	**11.23%**	8.95%	8.71%	10.97%
Liabilities growth limit	0.142	**9.51%**	7.46%	7.28%	9.31%
Expenditure/GDP ceiling	0.148	**11.28%**	8.99%	8.74%	11.01%

Note: For each type of policy constraint, "optimal value" corresponds to the best scenario (bolded). When combining fiscal rules, the revenue ceiling is chosen optimally; the primary deficit ceiling and the liabilities growth limit are set at their pre-reform values, zero and 3.6% *annual, respectively.*

significant reduction in government spending. Budget balance and debt rules are, by contrast, not very effective or beneficial. Revenue ceilings, however, have some unsavory macroeconomic consequences, which could limit their political appeal: debt and inflation (or default incentives) grow significantly. Furthermore, welfare could still be improved significantly. Combining the revenue ceiling with either a primary deficit ceiling or a limit on the growth rate of total government liabilities fixes these problems. Either of these combinations brings the benefits of fiscal rules very close to those obtained from a limit on expenditure.

Adverse shocks do not change the overall prescription. Effective fiscal rules curb the size of government but do not curtail its ability to smooth distortions over time. Key to this result is the ability to use monetary policy for stabilization purposes. For all rules and shocks considered here, the cost of suspension during bad times is low, though it is typically best to never suspend a rule.

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Appendix

A Derivation of monetary equilibrium conditions (2)–(6)

Here, we derive conditions (2)–(6) which characterize a monetary equilibrium. Let us start with the problem of an agent at night,

$$W(z, B, s) = \max_{c,n,m',b'} \gamma U(c) - \alpha n + v(g) + \beta E[V(m', b', B', s')|s]$$

subject to the budget constraint: $p_c c + (1 + \mu)(m' + qb') = p_c(1 - \tau)\zeta n + z$. Solving the budget constraint for n and replacing in the objective function, the first-order conditions imply:

$$\gamma U_c - \frac{\alpha}{(1-\tau)\zeta} = 0 \quad (20)$$

$$-\frac{\alpha(1+\mu)}{p_c(1-\tau)\zeta} + \beta E[V_m'|s] = 0 \quad (21)$$

$$-\frac{\alpha(1+\mu)q}{p_c(1-\tau)\zeta} + \beta E[V_b'|s] = 0 \quad (22)$$

The night-value function W is linear in z, $W_z = \frac{\alpha}{p_c(1-\tau)\zeta}$. Hence, $W(z, B, s) = W(0, B, s) + \frac{\alpha z}{p_c(1-\tau)\zeta}$, which we will use to rewrite the problem of the agent in the day. Accordingly, the problem of a consumer in the day can be rewritten as

$$V^c(m, b, B, s) = \max_x \ u(x) + W(0, B, s) + \frac{\alpha(m + b - p_x x)}{p_c(1-\tau)\zeta}$$

subject to the liquidity constraint $p_x x \leq m + \theta b$, with associated Lagrange multiplier ξ. The first-order condition is

$$u_x - \frac{\alpha p_x}{p_c(1-\tau)\zeta} - \xi p_x = 0 \quad (23)$$

Similarly, the problem of a producer can be rewritten as

$$V^p(m, b, B, s) = \max_\kappa \ -\phi\kappa + W(0, B, s) + \frac{\alpha(m + b + p_x\kappa)}{p_c(1-\tau)\zeta}$$

The first-order condition implies

$$-\phi + \frac{\alpha p_x}{p_c(1-\tau)\zeta} = 0 \quad (24)$$

Given $V(m, b, B, s) \equiv \eta V^c(m, b, B, s) + (1-\eta)V^p(m, b, B, s)$ and using (24) we obtain:

$$V_m = \phi/p_x + \eta\xi$$
$$V_b = \phi/p_x + \eta\theta\xi$$

Using these expressions, together with (24), we can rewrite (21) and (22) as

$$1 + \mu = \frac{\beta p_x E[\phi/p_x' + \eta\xi'|s]}{\phi} \quad (25)$$

$$q = \frac{E[\phi/p_x' + \eta\theta'\xi'|s]}{E[\phi/p_x' + \eta\xi'|s]} \quad (26)$$

In equilibrium, we have $m' = 1$ and $b' = B'$. Furthermore, the day and night resource constraints imply $\kappa = \eta/(1-\eta)x$ and $n = c + g$, respectively. The liquidity constraint of consumers in the day holds with equality (wlog if it does not bind); thus,

$$p_x = \frac{1+\theta B}{x} \tag{27}$$

which gives us (2).

Next, notice that (20) can be rearranged to yield (6):

$$\tau = 1 - \frac{\alpha}{\zeta\gamma U_c} \tag{28}$$

Plugging (27) and (28) into (24) yields (3):

$$p_c = \frac{\gamma U_c(1+\theta B)}{\phi x} \tag{29}$$

Given (27)–(29) we can solve for the Lagrange multiplier of the liquidity constraint:

$$\xi = \frac{(u_x - \phi)x}{(1+\theta B)} \tag{30}$$

Hence, (25) and (26) imply, respectively, (5) and (4), i.e.,

$$q = \frac{E[\frac{x'(\eta\theta' u'_x + (1-\eta\theta')\phi)}{1+\theta' B'}|s]}{E[\frac{x'(\eta u'_x + (1-\eta)\phi)}{1+\theta' B'}|s]}, \tag{31}$$

$$\mu = \frac{\beta(1+\theta B)}{\phi x} E\left[\frac{x'(\eta u'_x + (1-\eta)\phi)}{(1+\theta' B')}\middle| s\right] - 1 \tag{32}$$

B Discretionary government in non-stochastic economies

Consider a non-stochastic economy, i.e., when parameters $\{\gamma, \zeta, \theta, \omega\}$ are constant over time. Conditions (7)–(11) become:

$$\begin{aligned}
(\gamma U_c - \alpha/\zeta)\, c - (\alpha/\zeta)g - \frac{\phi x(1+B)}{1+\theta B} + \beta\frac{\phi x'(1+B')}{1+\theta B'} + \beta\eta x'(u'_x - \phi) &= 0 \\
\frac{\phi x'(1-\theta')(\lambda-\lambda')}{(1+\theta B')^2} + \lambda\mathcal{X}'_B\left[\eta(u'_x + u'_{xx}x' - \phi) + \frac{\phi(1+B')}{1+\theta B'}\right] &= 0 \\
\eta(u_x - \phi) - \frac{\lambda\phi(1+B)}{1+\theta B} &= 0 \\
\gamma U_c - \alpha/\zeta + \lambda\left\{\gamma U_c - \alpha/\zeta + \gamma U_{cc}c)\right\} &= 0 \\
v_g - \alpha/\zeta + \mathcal{R}_g - \lambda(\alpha/\zeta) &= 0
\end{aligned}$$

Note that we can normalize $\gamma = \zeta = 1$. It will be useful to define $1 + \hat{B} \equiv (1+B)/(1+\theta B)$ and write the Markov-perfect equilibrium as a function of $\hat{B}$ instead of B. This implies a set of equilibrium functions $\{\hat{\mathcal{B}}, \hat{\mathcal{X}}, \hat{\mathcal{C}}, \hat{\mathcal{G}}, \hat{\Lambda}\}$. Note that $\mathcal{X}_B = \hat{\mathcal{X}}_B(1+\theta B)^2/(1-\theta)$. We thus get,

$$(U_c - \alpha)\, c - \alpha g - \phi x(1+\hat{B}) + \beta\phi x'(1+\hat{B}') + \beta\eta x'(u'_x - \phi) = 0 \tag{33}$$

$$\phi x'(\lambda - \lambda') + \lambda\hat{\mathcal{X}}'_B[\eta(u'_x + u'_{xx}x' - \phi) + \phi(1+\hat{B}')] = 0 \tag{34}$$

$$\eta(u_x - \phi) - \lambda\phi(1+\hat{B}) = 0 \tag{35}$$

$$U_c - \alpha + \lambda\left\{U_c - \alpha + U_{cc}c)\right\} = 0 \tag{36}$$

$$v_g - \alpha + \mathcal{R}_g - \lambda\alpha = 0 \tag{37}$$

When characterized in terms of $\hat{B}$, the equilibrium is independent of θ. Hence, the equilibrium is equivalent to the one studied in Martin (2011), which assumed $\theta = 0$, and we can apply the results derived there—the addition here of $R(g, \omega)$ is immaterial for the equivalence result since, from Assumption 1, it can be viewed as being subsumed in the function $v(g)$. Two results apply. First, the proof of Proposition 1 here follows from Proposition 5 in Martin (2011). Second, when restricting the debt state space to be above -1, there is a unique steady state $\hat{B}^*$.[23] Proposition 2 in Martin (2011) shows that $\hat{B}^* > -1$, $\hat{\Lambda}(\hat{B}^*) > 0$ and $\hat{\mathcal{X}}_B(\hat{B}^*) < 0$; Propositions 3 and 4 establish further properties, including stability under certain conditions. Despite the variable transformation, the actual steady state bond-to-money ratio has the same property $B^* > -1$. Thus, when defining the set $\Gamma = [\underline{B}, \overline{B}]$, let $-1 < \underline{B} < B^* < \overline{B} < \infty$.

Given the discussion above, after some work, equations (33)–(37) imply a steady state level of debt,

$$B^* = -\frac{1 + \eta\Phi(x^*)}{1 + \theta\eta\Phi(x^*)} \tag{38}$$

where $\Phi(x^*) \equiv \frac{u_x^* + u_{xx}^* x^*}{\phi} - 1$ and $\{x^*, c^*, g^*\}$ jointly solve

$$\begin{aligned}
(U_c^* - \alpha)\, c^* - \alpha g^* + \eta x^*[u_x^* - \phi + (1-\beta)u_{xx}^* x^*] &= 0 \\
\alpha(u_x^* - \phi) + (v_g^* + \mathcal{R}_g^* - \alpha)(u_x^* + u_{xx}^* x^* - \phi) &= 0 \\
(v_g^* + \mathcal{R}_g^*)(U_c^* - \alpha) + (v_g^* + \mathcal{R}_g^* - \alpha)U_{cc}^* c^* &= 0
\end{aligned}$$

The steady state in a non-stochastic economy with a discretionary government can thus be solved locally by finding the solution to the system above.

C Defining macroeconomic variables

In this section, the macroeconomic variables defined in Section 4.1 are expressed in terms of debt and allocations.

Nominal output is defined as $Y_t \equiv p_{x,t}\eta x_t + p_{c,t}(c_t + g_t)$, which using (2) and (3) implies

$$Y_t = \frac{(1 + \theta_t B_t)[\eta\phi x_t + \gamma_t U_{c,t}(c_t + g_t)]}{\phi x_t}. \tag{39}$$

The price level is defined as $P_t \equiv \varsigma_x^* p_{x,t} + \varsigma_c^* p_{c,t}$, where ς_x^* and ς_c^* are the corresponding expenditure shares in the non-stochastic steady state (B^*, x^*, c^*, g^*). Using (2) and (3) we obtain

$$P_t = \frac{(1 + \theta_t B_t)(\varsigma_x^*\phi + \varsigma_c^*\gamma_t U_{c,t})}{\phi x_t}. \tag{40}$$

Expected inflation is defined as $\pi_{t+1}^e \equiv E_t[P_{t+1}](1 + \mu_t)/P_t - 1$. Using (5) and (40) we get

$$\pi_{t+1}^e = \beta E_t\left[\frac{(1 + \theta_{t+1}B_{t+1})(\varsigma_x^*\phi + \varsigma_c^*\gamma_{t+1}U_{c,t+1})}{\phi x_{t+1}(\varsigma_x^*\phi + \varsigma_c^*\gamma_t U_{c,t})}\right] E_t\left[\frac{x_{t+1}(\eta u_{x,t+1} + (1-\eta)\phi)}{(1 + \theta_{t+1}B_{t+1})}\right] - 1. \tag{41}$$

The nominal interest rate is defined as $i_t \equiv q_t^{-1} - 1$. Hence, from (4):

$$i_t = \frac{E_t[\frac{x_{t+1}(\eta u_{x,t+1} + (1-\eta)\phi)}{1+\theta_{t+1}B_{t+1}}]}{E_t[\frac{x_{t+1}(\eta\theta_{t+1}u_{x,t+1} + (1-\eta\theta_{t+1})\phi)}{1+\theta_{t+1}B_{t+1}}]} - 1. \tag{42}$$

[23] There is an infinite number of steady states below -1, including one which implements the first-best allocation.

Government expenditure (excluding interest payments) in terms of GDP is $\upsilon_t \equiv p_{c,t}g_t/Y_t$, Using (3) and (39) we obtain

$$\upsilon_t = \frac{\gamma_t U_{c,t} g_t}{\eta\phi x_t + \gamma_t U_{c,t}(c_t + g_t)} \tag{43}$$

Revenue over GDP is defined as $\rho_t \equiv p_{c,t}\tau_t(c_t + g_t)/Y_t$. Using (3), (6) and (39) is can be expressed as

$$\rho_t = \frac{(\gamma_t U_{c,t} - \alpha/\zeta_t)(c_t + g_t)}{\eta\phi x_t + \gamma_t U_{c,t}(c_t + g_t)} \tag{44}$$

The primary deficit over GDP is defined as $d_t \equiv p_{c,t}[g_t - \tau_t(c_t + g_t)]/Y_t$. Using (3), (6) and (39) we obtain

$$d_t = \frac{(\alpha/\zeta_t)(c_t + g_t) - \gamma_t U_{c,t} c_t}{\eta\phi x_t + \gamma_t U_{c,t}(c_t + g_t)}. \tag{45}$$

The deficit over GDP is defined as $D_t \equiv d_t + \frac{(1+\mu_t)(1-q_t)B_{t+1}}{Y_t}$. Using (4), (5), (39) and (45) we get

$$D_t = \frac{(\alpha/\zeta_t)(c_t + g_t) - \gamma_t U_{c,t} c_t + \beta\eta B_{t+1} E_t[\frac{(1-\theta_{t+1})x_{t+1}(u_{x,t+1}-\phi)}{(1+\theta_{t+1}B_{t+1})}]}{\eta\phi x_t + \gamma_t U_{c,t}(c_t + g_t)}. \tag{46}$$

Debt is measured at the end of the period, as in the data. Thus, debt-over-GDP is

$$\frac{(1+\mu_t)B_{t+1}}{Y_t} = \frac{\beta B_{t+1}}{\eta\phi x_t + \gamma_t U_{c,t}(c_t + g_t)}\ E_t\left[\frac{x_{t+1}(\eta u_{x,t+1} + (1-\eta)\phi)}{(1+\theta_{t+1}B_{t+1})}\right] \tag{47}$$

Finally, the growth rate of total (nominal) government liabilities is defined as $\ell_t \equiv (1 + \mu_t)(1 + B_{t+1})/(1 + B_t) - 1$, which using (5) implies

$$\ell_t = \frac{\beta(1+\theta_t B_t)}{\phi x(1+B_t)} E_t\left[\frac{x_{t+1}(1+B_{t+1})(\eta u_{x,t+1} + (1-\eta)\phi)}{(1+\theta_{t+1}B_{t+1})}\right] - 1 \tag{48}$$

D Constraints on allocations

The exercises conducted in the main body of the paper consist of placing constraints on *policy variables*, e.g., a revenue ceiling or a debt limit. Alternatively, one could imagine placing constraints on *allocations*. Constraining allocations, such as day-good and night-good consumption, is simple to implement, but sacrifices realism and hence, the usefulness of the resulting policy prescriptions. Constraining public expenditure g directly was assumed to be infeasible as that would essentially resolve the political friction at (virtually) no cost.

It is instructive, however, to consider optimal constraints on allocations and compare them to the policy rules studied in the paper. Moreover, there is a mapping between allocations and policy variables. To keep things simple, consider the case without aggregate shocks. First, targeting x is equivalent to targeting current inflation in the day market. To see this, note that inflation in the day market is $\pi_t^x \equiv p_{x,t}(1 + \mu_{t-1})/p_{x,t-1} - 1$, which using (2) and (5) implies $\pi_t^x = \beta(\eta u_{x,t}/\phi + 1 - \eta) - 1$. Second, from (6), targeting the night good c is equivalent to targeting the tax rate τ.

Here, I consider three types of constraints: a day-good inflation target ($x = x^T$ or, equivalently $\pi^x = \pi^T$); a ceiling on the tax rate ($c \leq \bar{c}$ or, equivalently, $\tau \leq \bar{\tau}$); and a ceiling on public expenditure ($g \leq \bar{g}$). Table D.1 presents the results, which should be compared to Tables 3 and 4. As we can see, the tax rate ceiling performs similarly to the revenue ceiling, in terms of macroeconomic outcomes and welfare, but offers lower welfare. Thus, a revenue ceiling is still preferred. An expenditure ceiling also underperforms relative to a ceiling on public expenditure over GDP.

Table D.1: Optimal allocation constraints and steady state statistics—benchmark calibration

Variable / Constraint	Day-market inflation target $x = x^T$	Tax rate ceiling $c \leq \bar{c}$	Expenditure ceiling $g \leq \bar{g}$
Optimal constraint	0.017	0.170	0.103
Welfare gains	0.09%	1.82%	9.93%
Steady State	0.16%	1.09%	10.08%
Transition	−0.07%	0.74%	−0.15%
Steady state statistics			
Debt over GDP	0.305	0.480	0.318
Inflation rate	0.017	0.120	0.018
Nominal interest rate	0.046	0.108	0.047
Liquidity spread	0.030	0.077	0.030
Revenue over GDP	0.185	0.151	0.149
Expenditure over GDP	0.180	0.172	0.144
Nominal debt	1.593	3.139	1.516
Real interest rate	0.029	−0.011	0.028
Primary deficit over GDP	−0.005	0.021	−0.005
Deficit over GDP	0.008	0.068	0.009

E Optimal fiscal rules: policies, allocations and welfare

The charts in this section correspond to the benchmark calibration of the non-stochastic economy—see Table 1. The charts show how policies, allocations and welfare are affected by the introduction of a particular fiscal rule, for any level of debt. For each fiscal rule considered, there are two sets of charts. The first set displays panels for debt, primary deficit over GDP, revenue over GDP, expenditure over GDP, inflation rate and nominal interest rate. Here, the constrained equilibrium is compared to the unconstrained case (labeled "discretion"). The second set displays panels with allocations (x, c and g) and welfare gains. All variables are expressed as functions of debt, B and shown for the entire computed state space, $\Gamma = [0, 4]$.

Despite the introduction of fiscal rules, there are no kinks in the allocation functions, $\mathcal{X}(B)$, $\mathcal{C}(B)$ and $\mathcal{G}(B)$; kinks in $\mathcal{X}$ could have proven problematic as $\mathcal{X}'_B$ enters the Generalized Euler Equation (GEE). The debt function, $\mathcal{B}(B)$, does have one kink then there is a debt rule. Note that the derivative of the debt function does not appear in the GEE; however, kinks in debt functions could translate into kinks in value functions, which would invalidate the envelope condition used to derive the GEE. However, value functions are smooth. First, future inflation "convexifies" kinks in future debt functions (as would lotteries). Second, the kink in the debt function occurs at the constrained steady state; hence, a government coming with lower or higher debt converges to the steady state, without internalizing the kink.

Figure E.1: Optimal revenue ceiling: policies

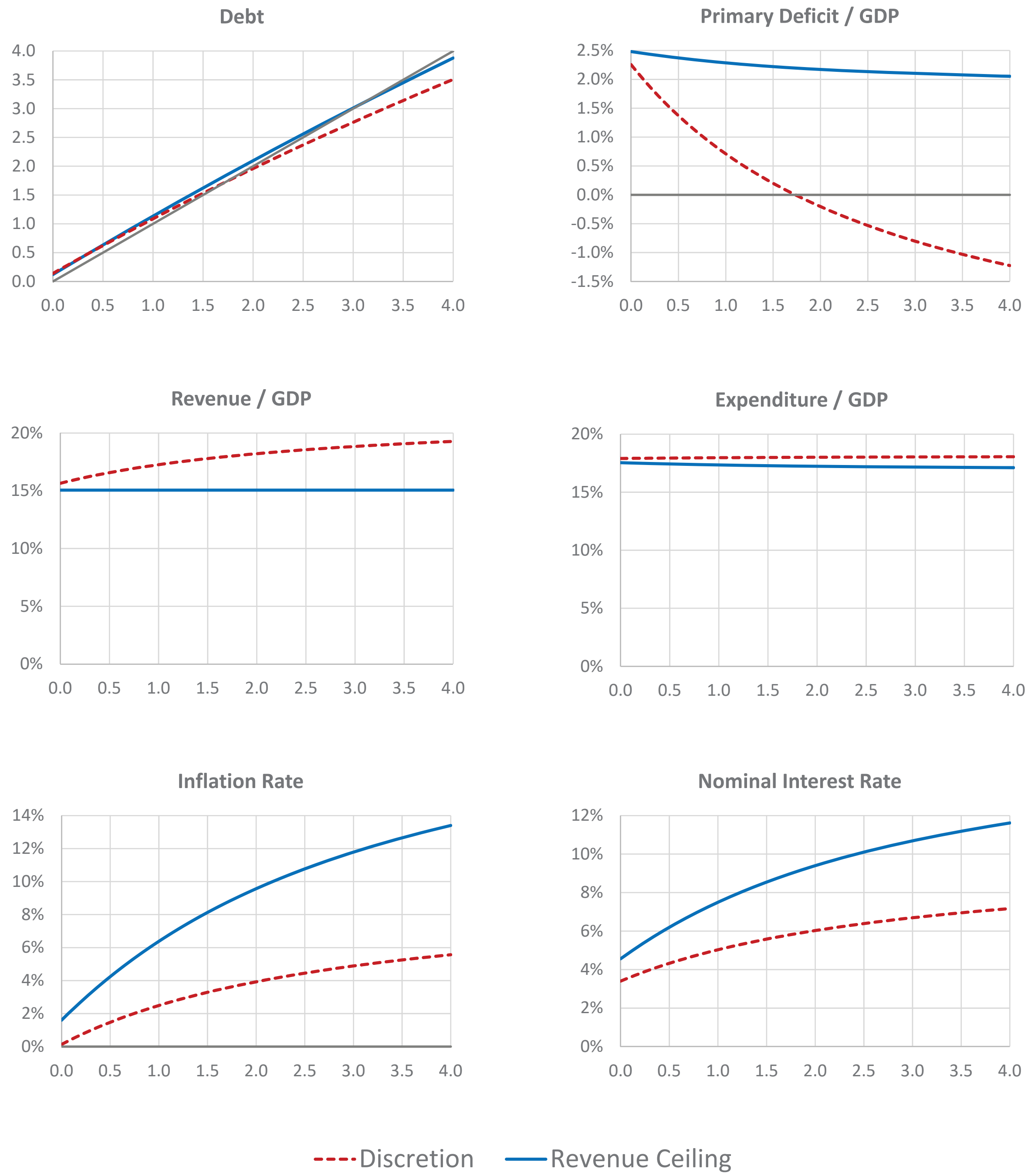
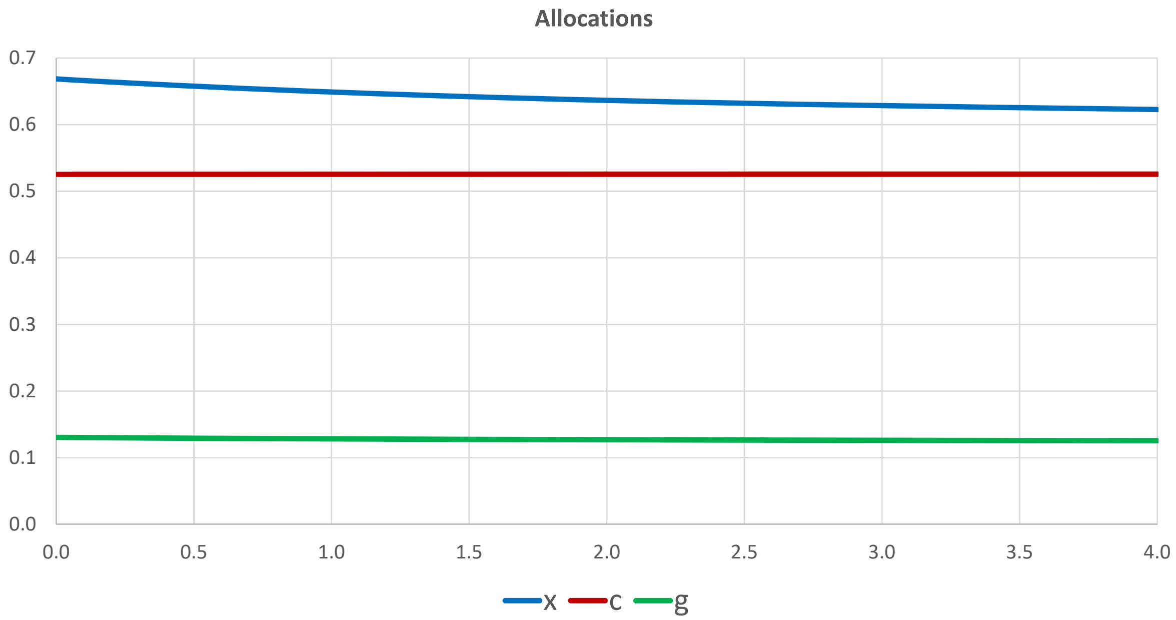


Figure E.2: Optimal revenue ceiling: allocations and welfare



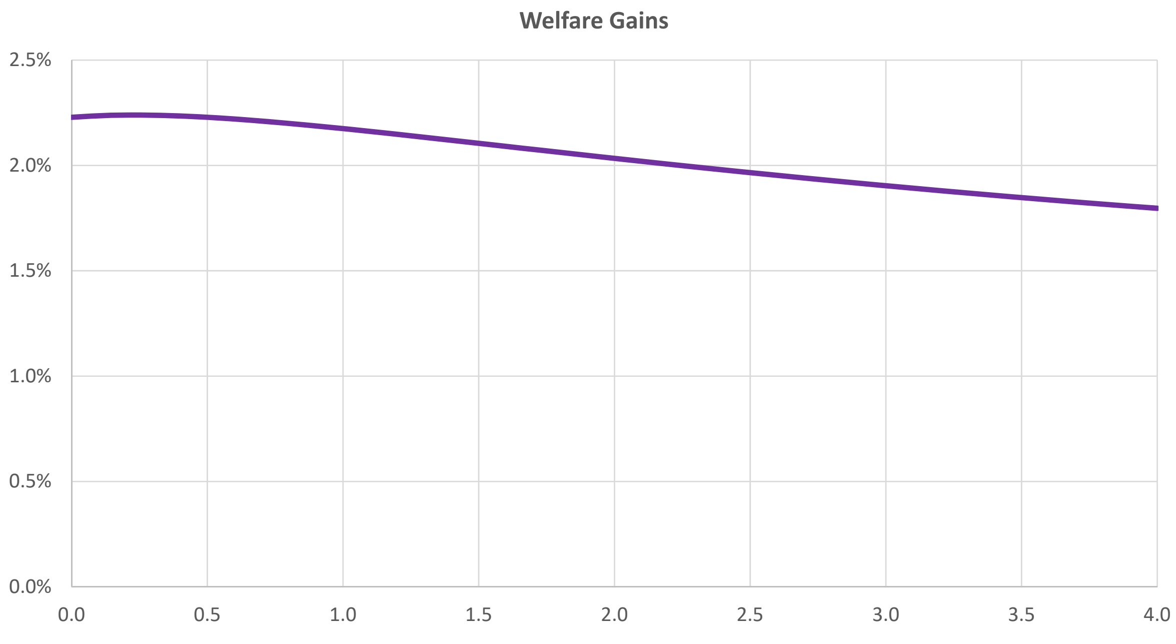


Figure E.3: Optimal primary deficit ceiling: policies

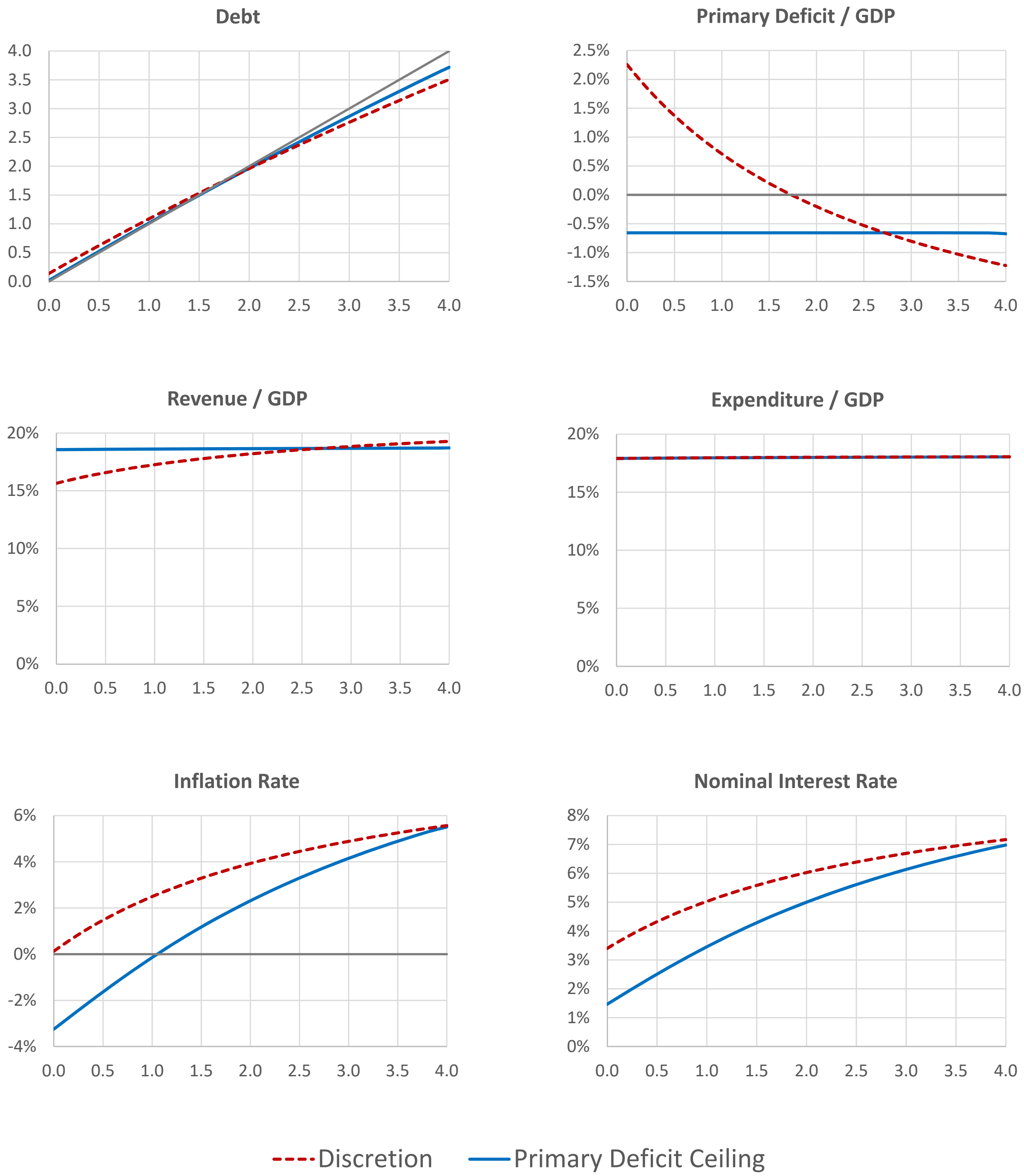
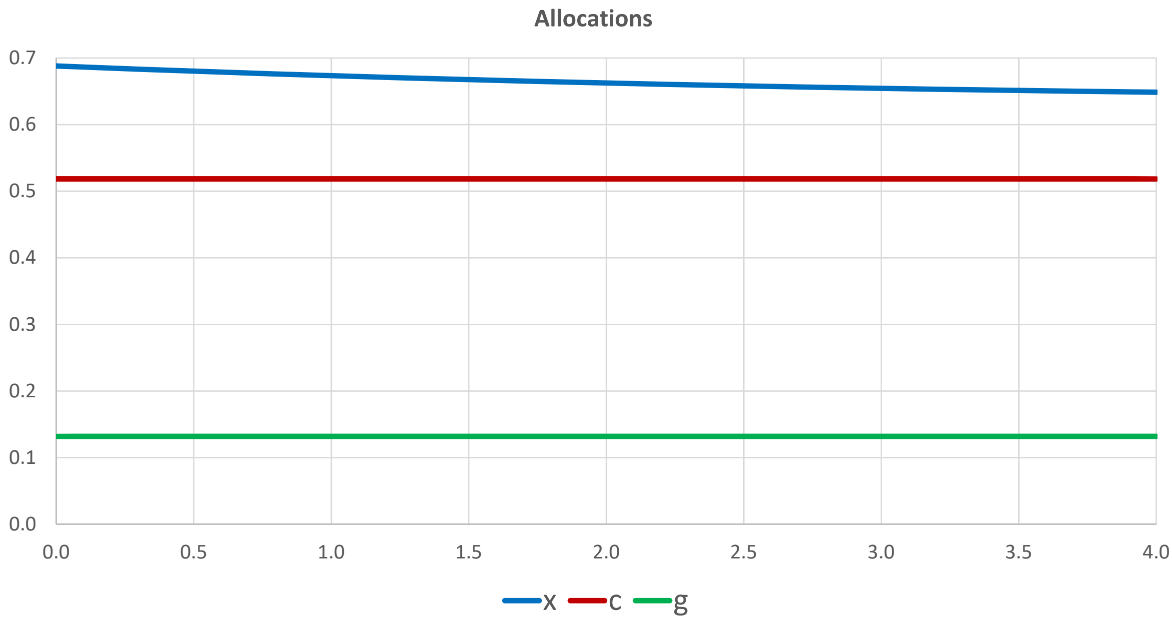


Figure E.4: Optimal primary deficit ceiling: allocations and welfare



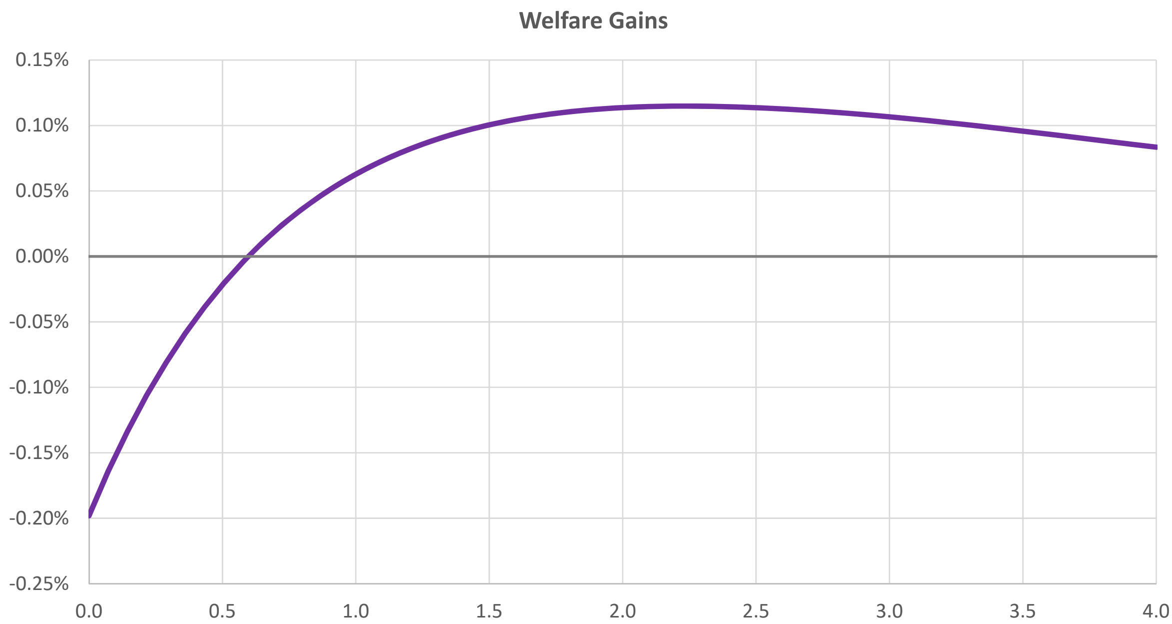


Figure E.5: Optimal deficit ceiling: policies

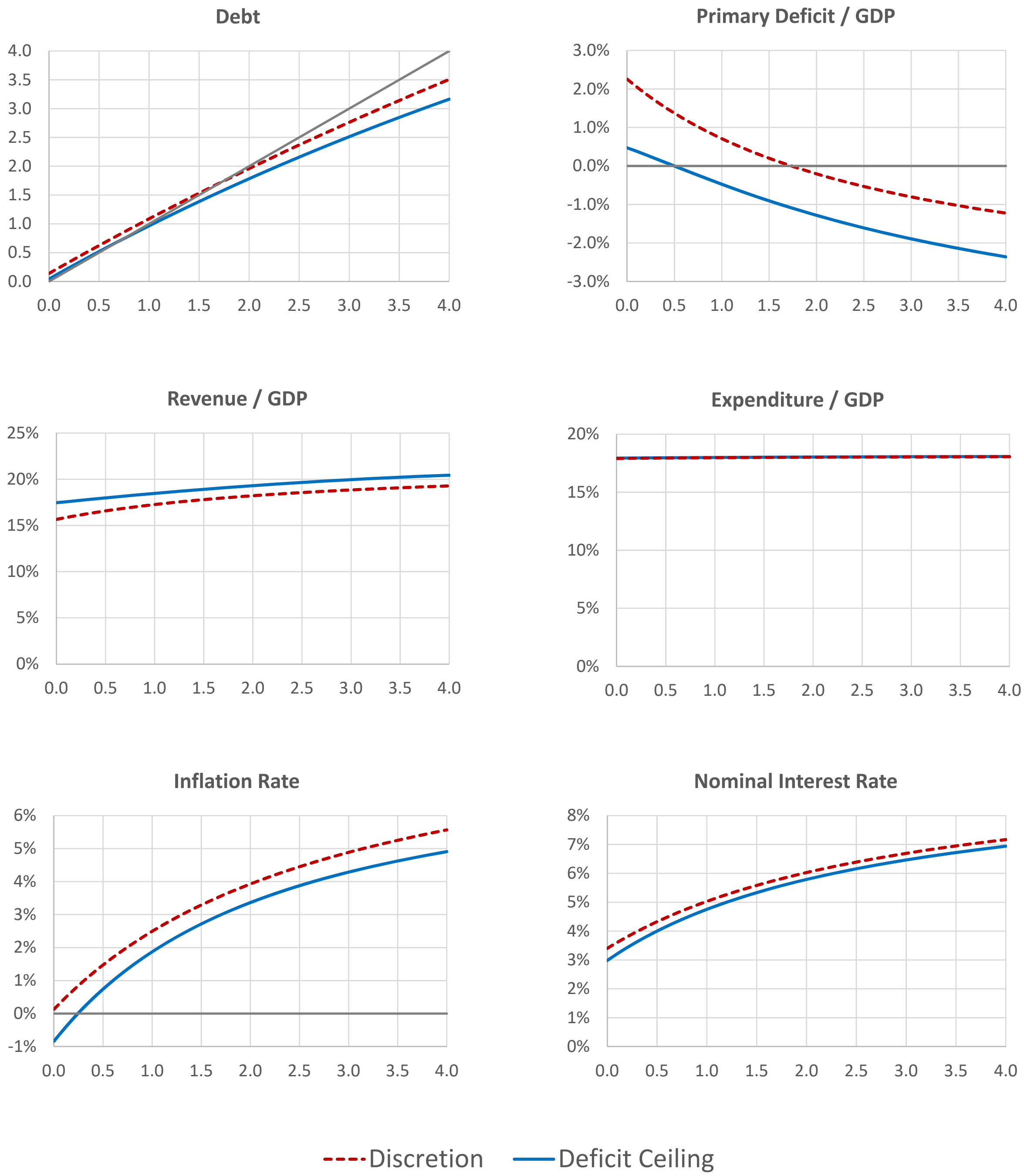


Figure E.6: Optimal deficit ceiling: allocations and welfare

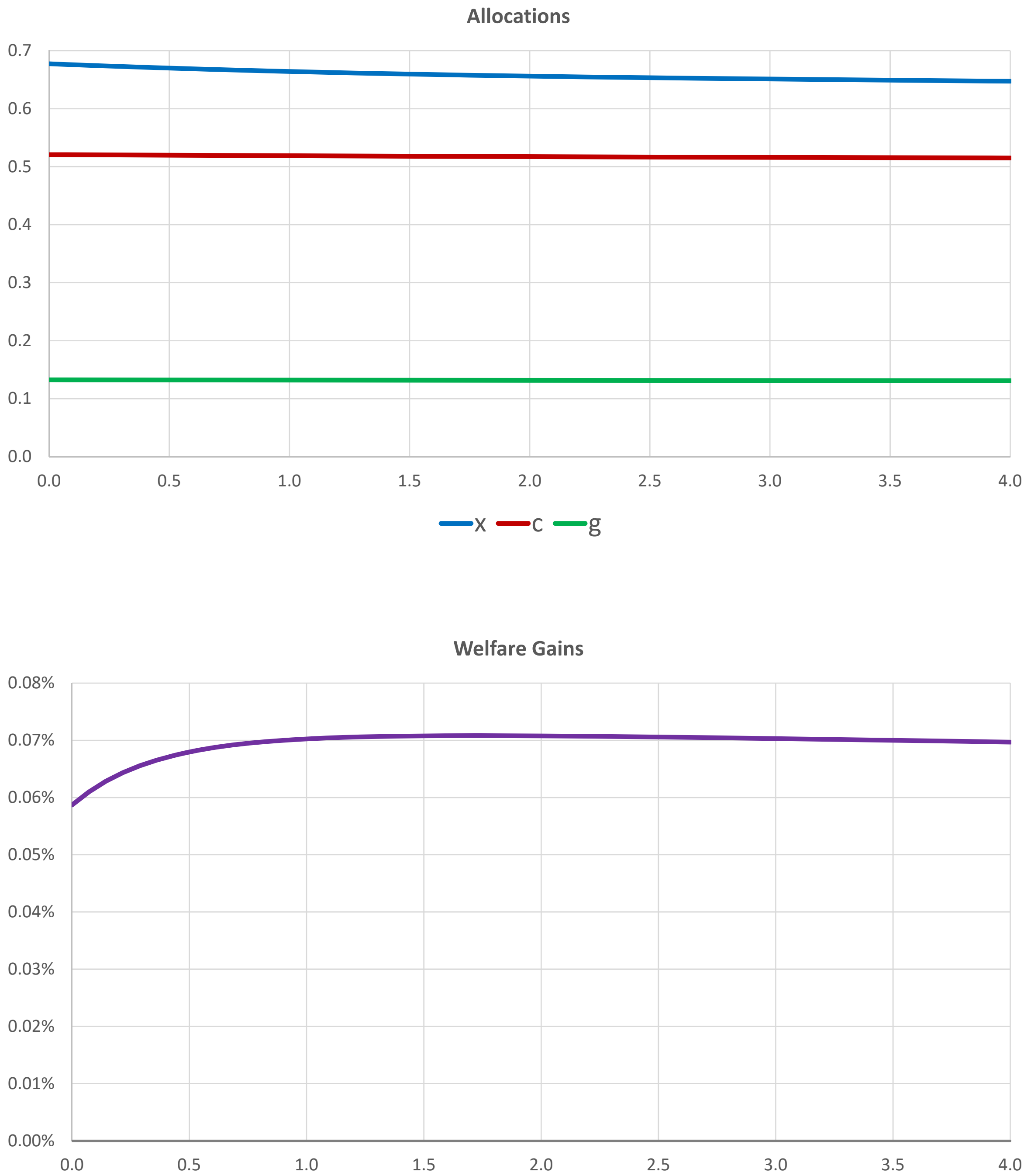


Figure E.7: Optimal debt over GDP limit: policies

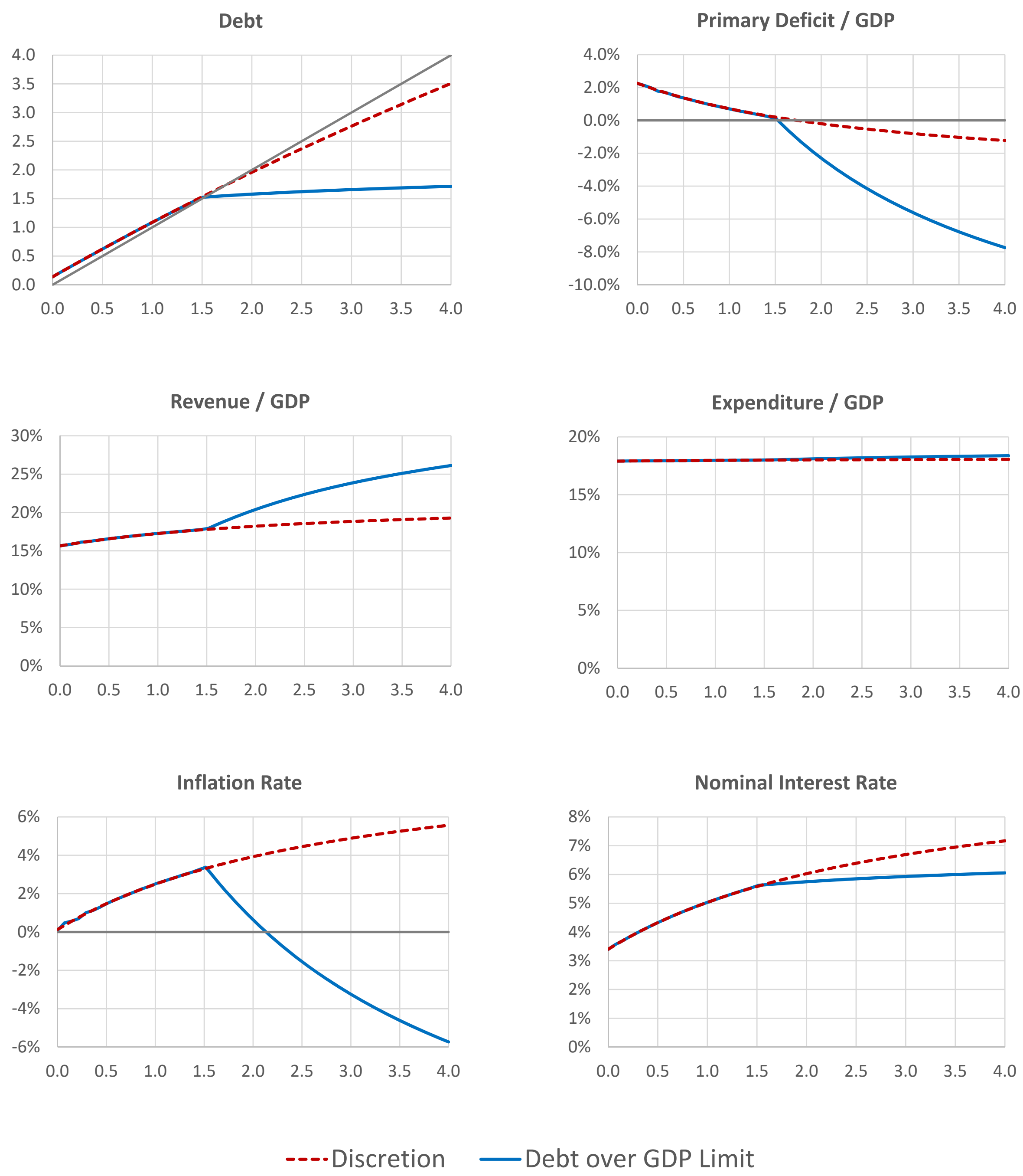
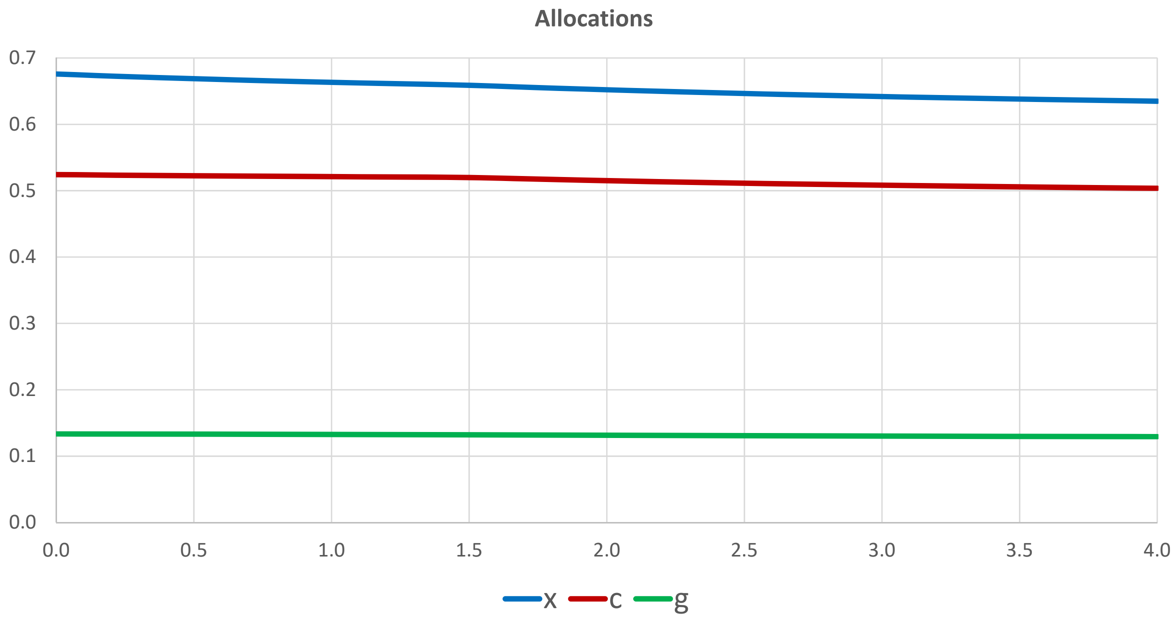


Figure E.8: Optimal debt over GDP: allocations and welfare



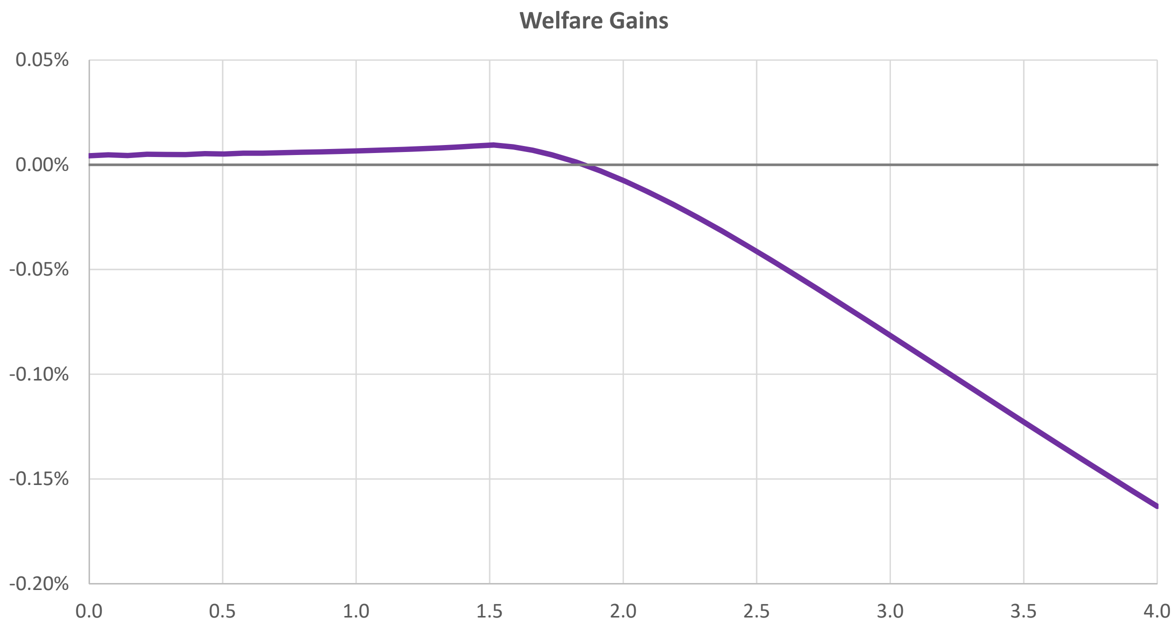


Figure E.9: Optimal debt ceiling: policies

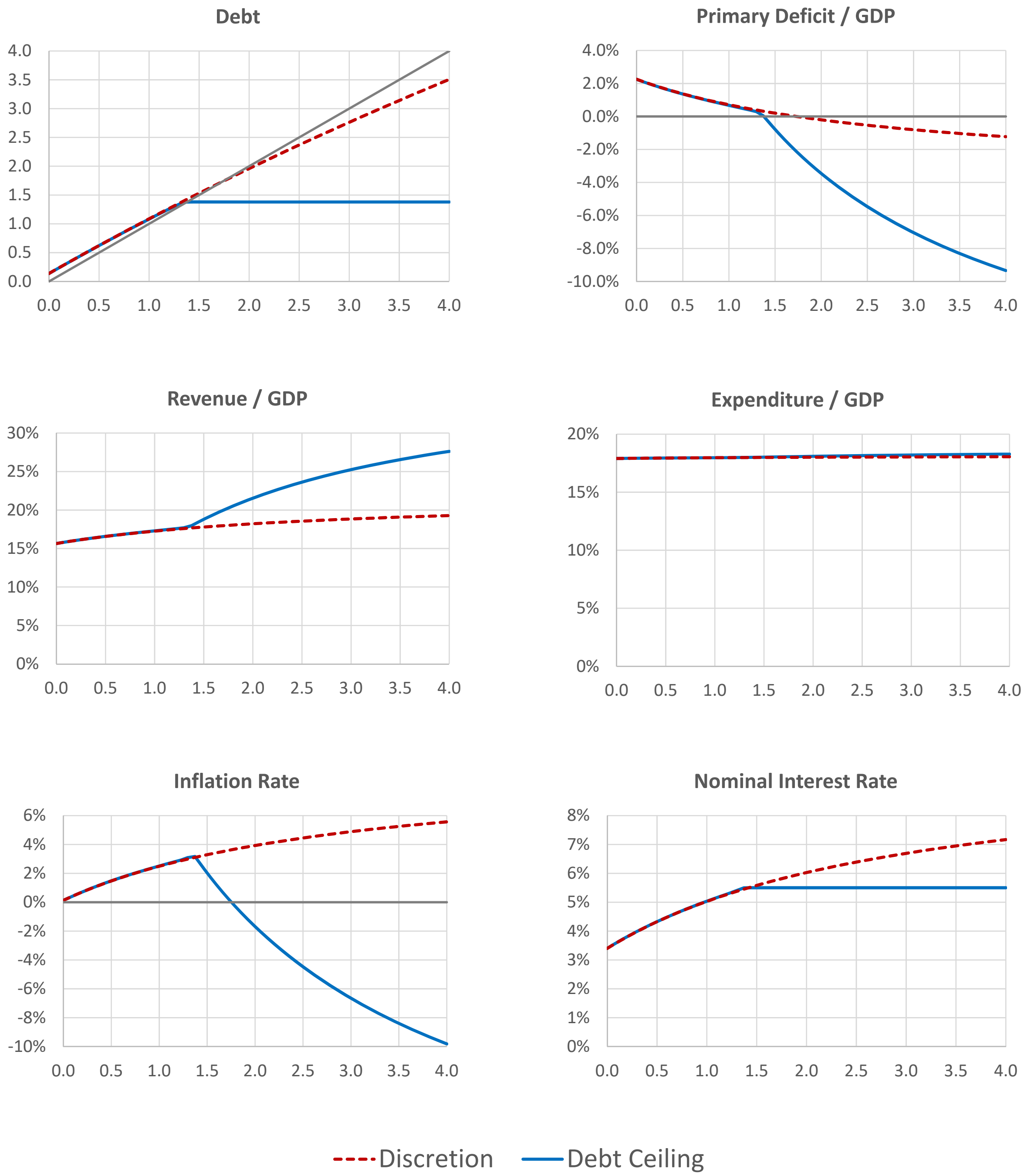


Figure E.10: Optimal debt ceiling: allocations and welfare

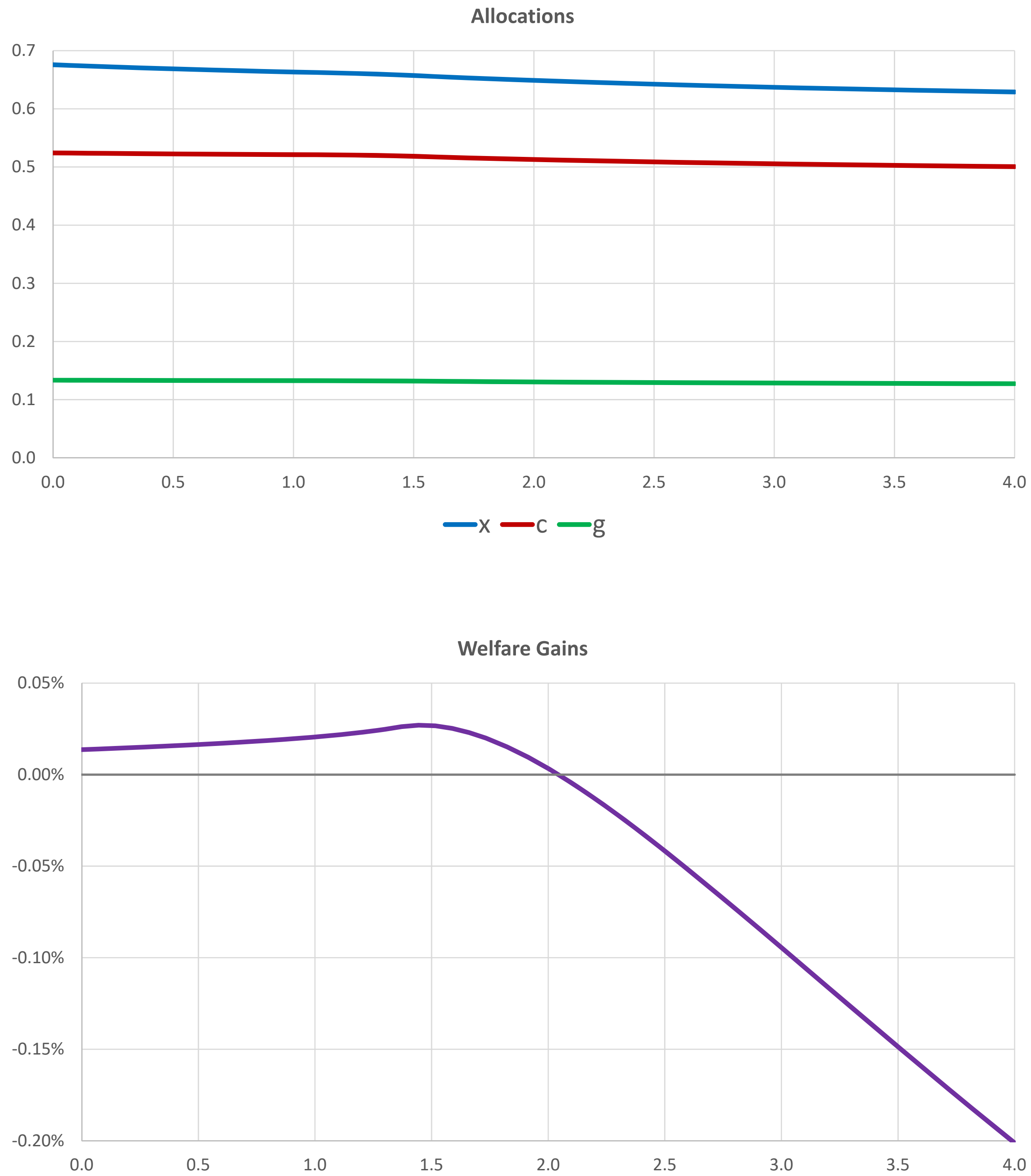


Figure E.11: Optimal liabilities growth limit: policies

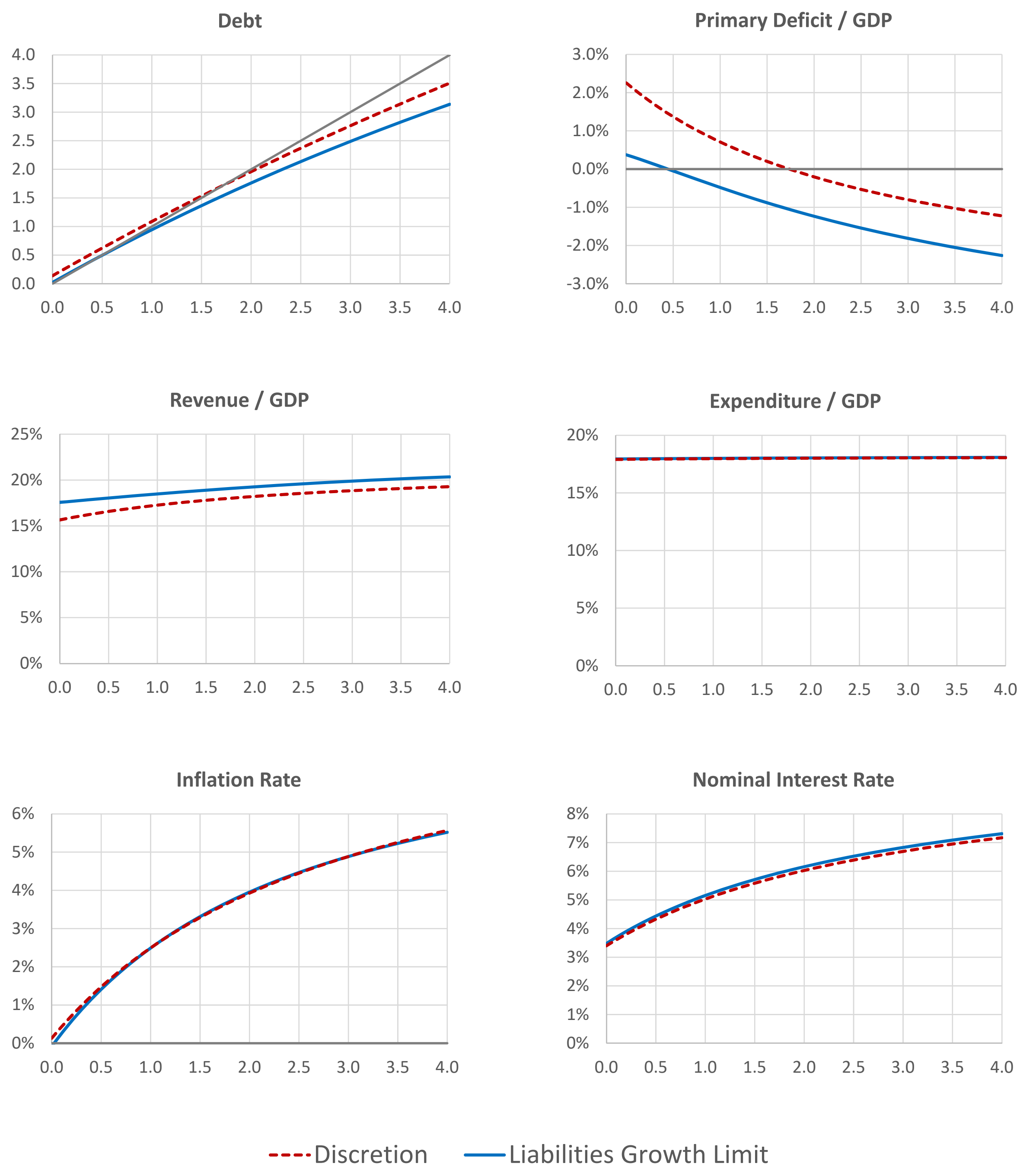


Figure E.12: Optimal liabilities growth limit: allocations and welfare

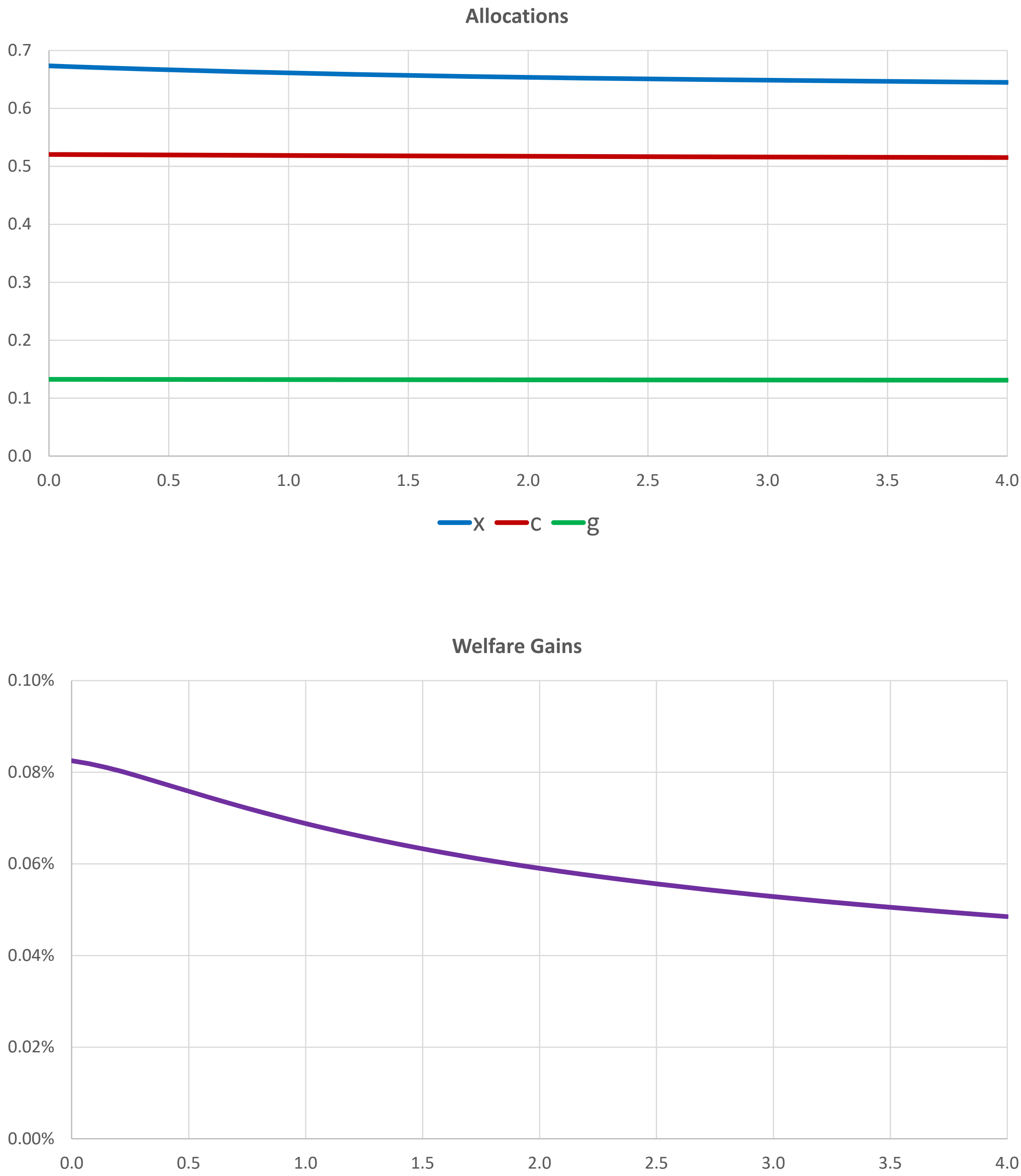


Figure E.13: Optimal revenue ceiling + primary deficit ceiling: policies

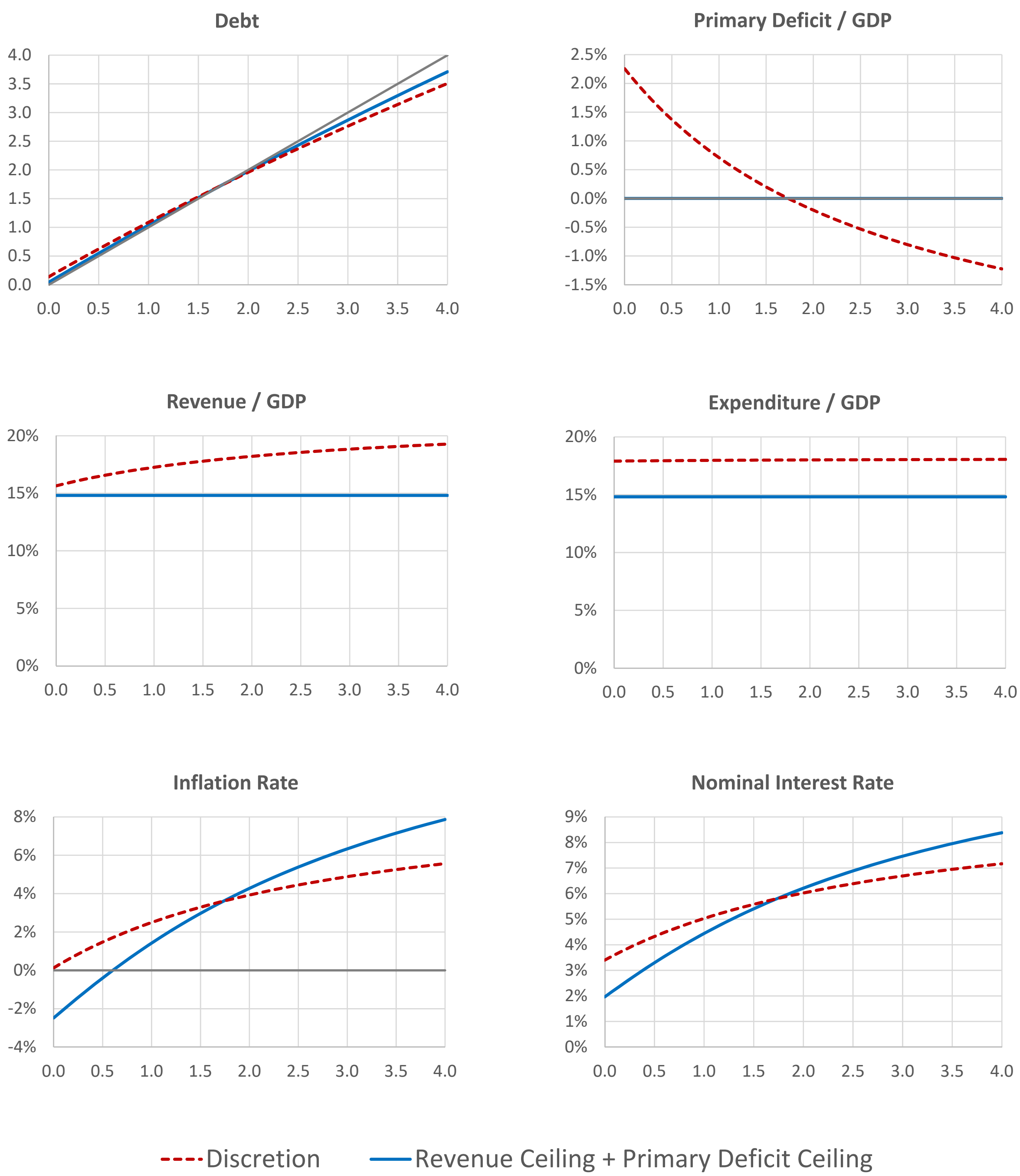
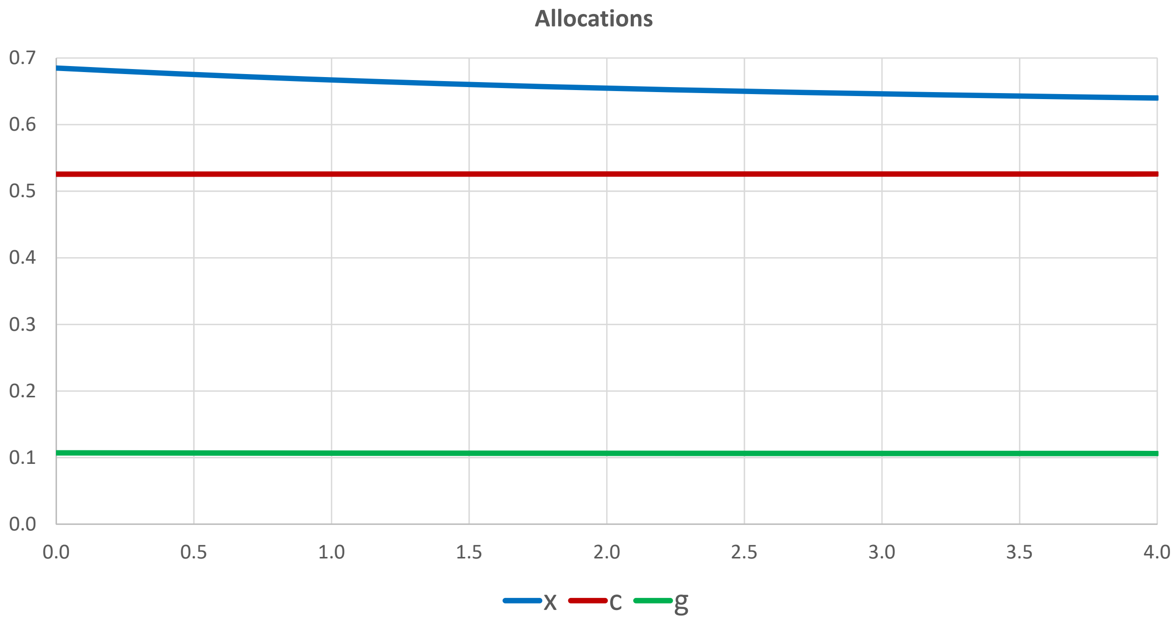


Figure E.14: Optimal revenue ceiling + primary deficit: allocations and welfare



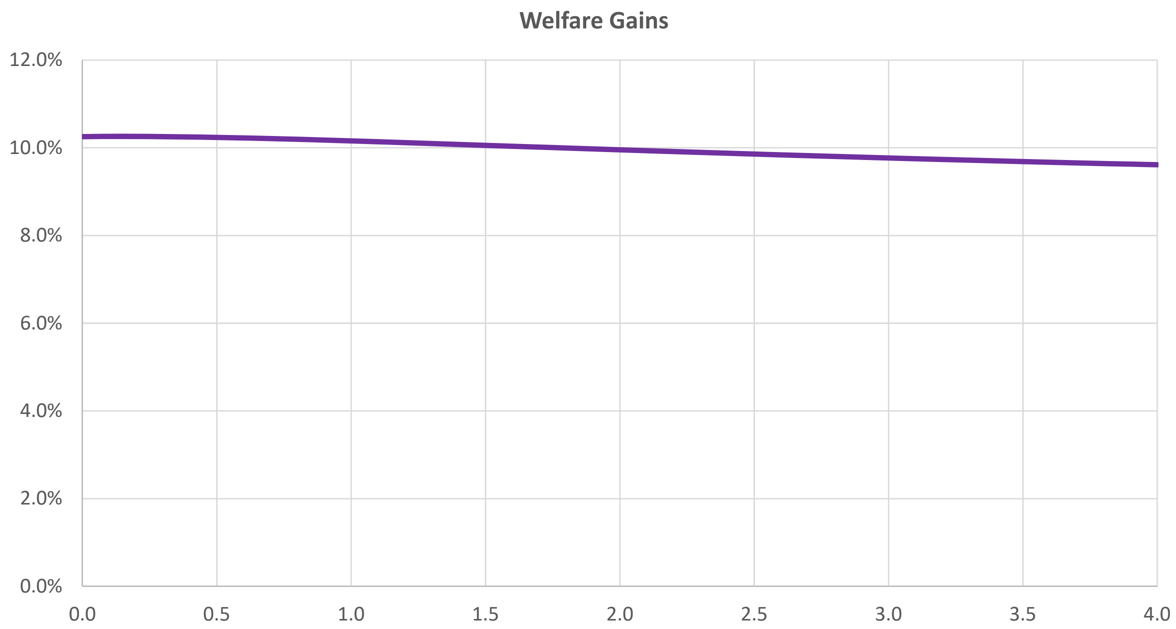


Figure E.15: Optimal revenue ceiling + liabilities growth limit: policies

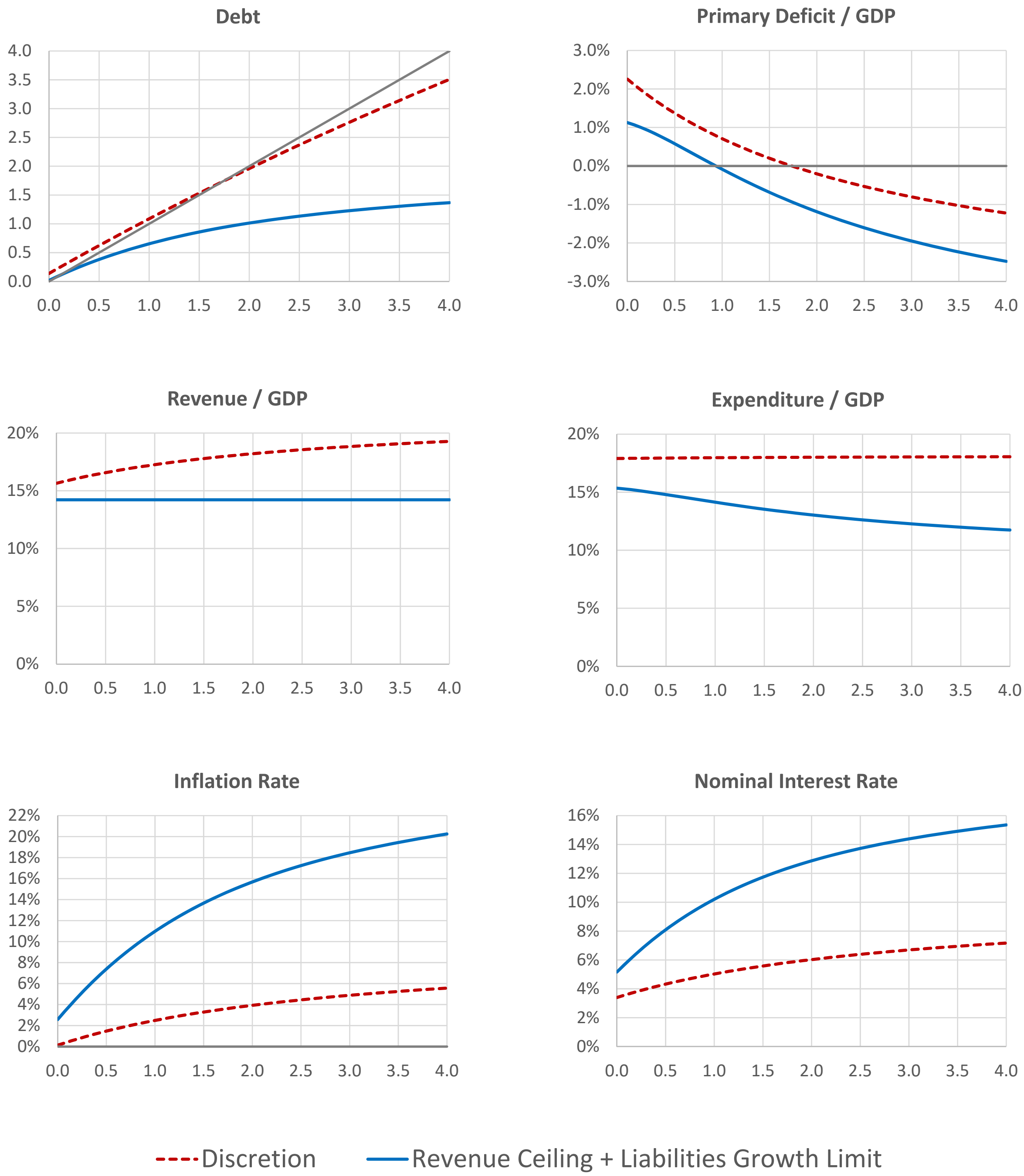
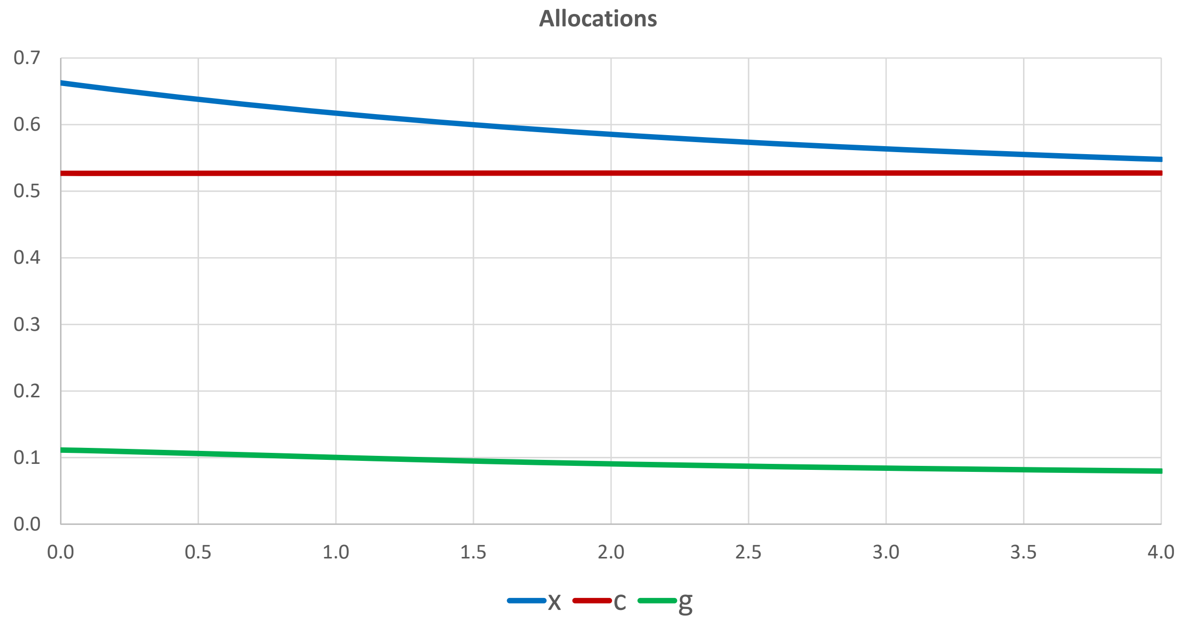


Figure E.16: Optimal revenue ceiling + liabilities growth limit: allocations and welfare



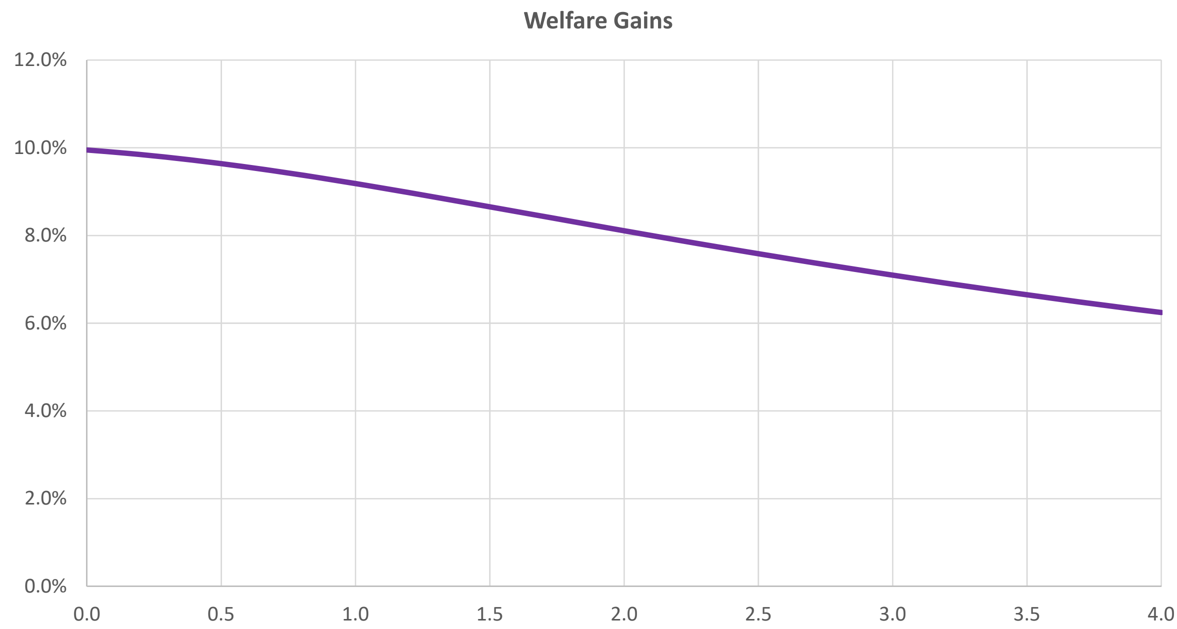


Figure E.17: Optimal expenditure ceiling: policies

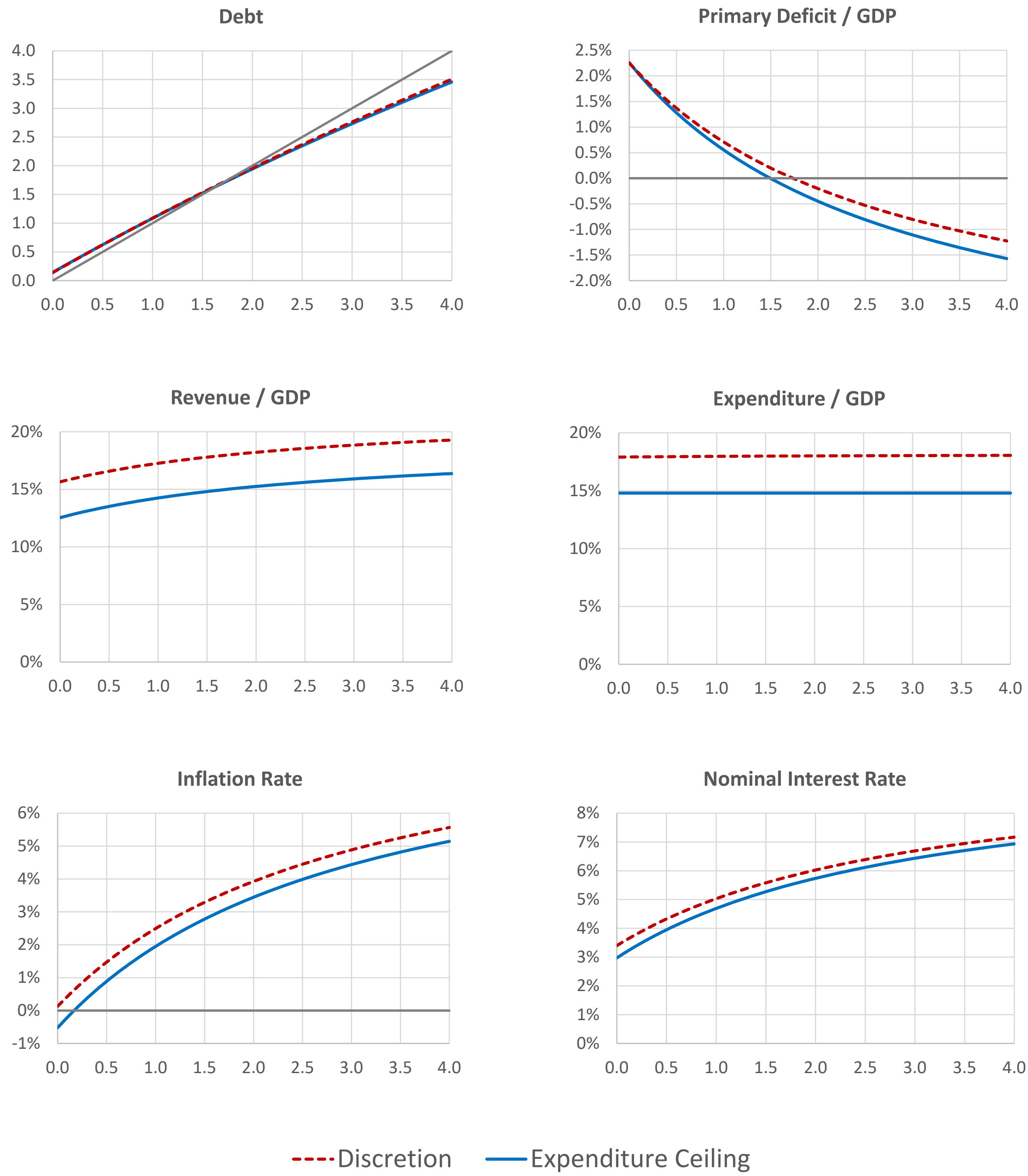
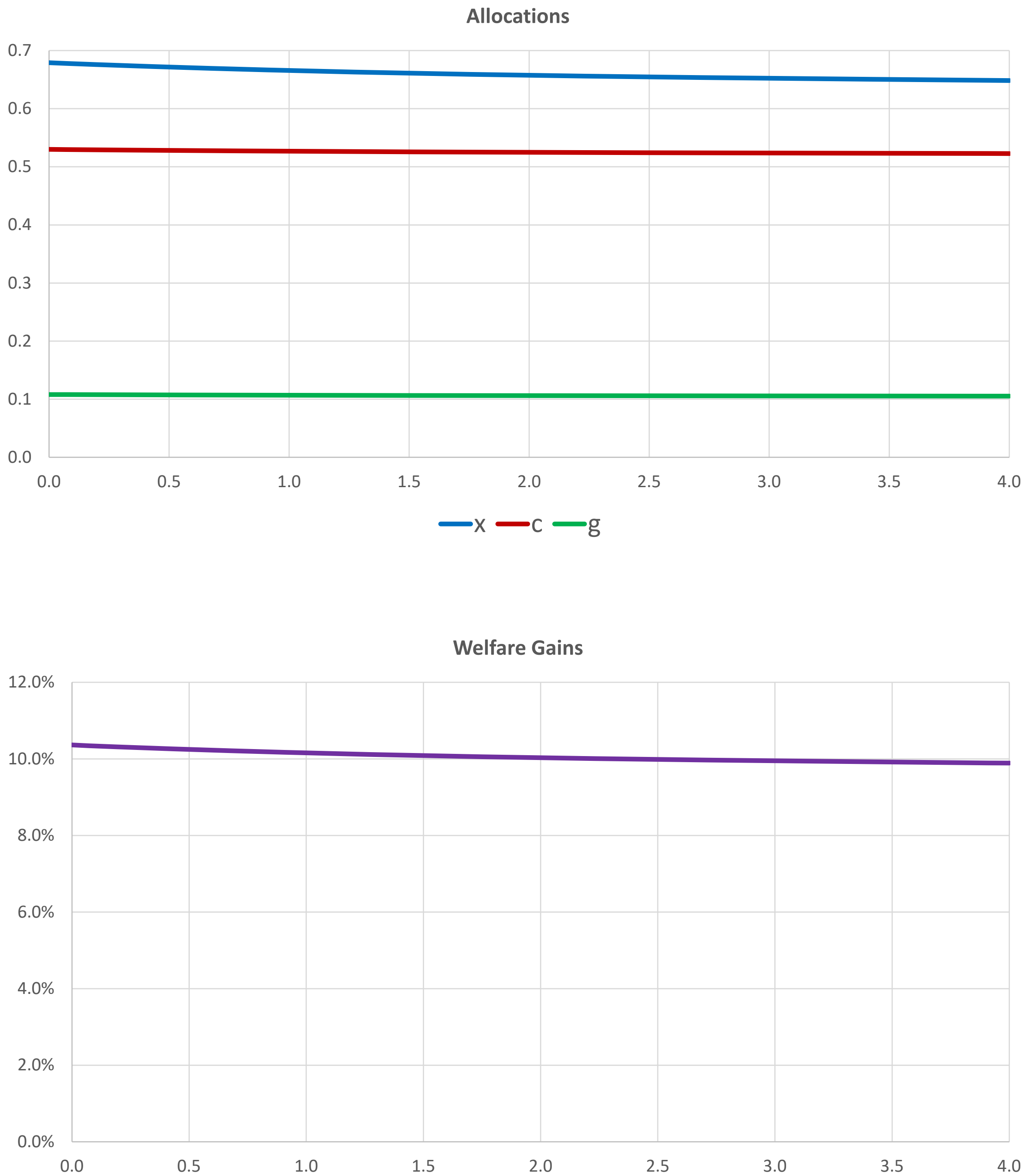


Figure E.18: Optimal expenditure ceiling: allocations and welfare



F Alternative calibrations

This section studies alternative calibrations to verify the robustness of the results presented in Section 6. The parameters for these calibrations are presented in Table F.1, while the corresponding steady state statistics are presented in Table F.2. Table F.3 provides the optimal values for policy rules.

The first alternative is an economy with a less benevolent government, when $\omega = 0.235$. In this case, public expenditure over GDP is 21%, i.e., 3 percentage points higher than the calibrated economy and 6 percentage higher than the benevolent economy. As a result, inflation, deficits and debt are all higher. When compared to the benchmark economy, the optimal constraints are all stricter when facing a less benevolent government. Since the potential gains are larger the less benevolent the government is, the costs imposed on it through constraints are optimally larger. As a result, welfare gains for all types of constraints increase by about an order of magnitude. Notably, however, the welfare ranking of constraints remains the same; the best prescription is still a revenue ceiling, about 13% of GDP in this case, which is even lower than revenue in the benevolent economy (about 15% of GDP). Welfare gains due to imposing the optimal revenue ceiling are worth about 11% of consumption. When combining a revenue ceiling with a primary deficit ceiling, welfare gains rise to 74.5%; these gains drop to 61.4% when the revenue ceiling is paired with a liabilities growth limit. Potential gains for this calibration are 76% of consumption; thus, the gains from the optimal fiscal rules, though larger in absolute terms, are relatively lower than in the benchmark case.

Next, I consider a calibration that delivers a steady state inflation of 2% annual. Arguably, inflation is the one policy variable that in the last two decades looks significantly different from the postwar average.[24] The degree of government benevolence, ω is set so that with the "low inflation" parameterization, a benevolent government (one with $\omega = 1$) would have the same expenditure over GDP as with the benchmark parameterization, 14.8% of GDP. This approach keeps the implied magnitude of the political distortion the same as in the benchmark case, though with a different policy mix. As we can see in Table F.2, inflation and the nominal interest rate are lower, consistent with the new targets, but fiscal variables are the same as in the benchmark economy. The government in the low inflation economy is slightly more benevolent than in the benchmark economy, but not dramatically so.

The lessons from the benchmark economy apply to the low inflation economy: the best single constraint is to impose a revenue ceiling (also 15.1% of GDP in this case). One notable difference between the benchmark and low inflation economies is that the optimal debt constraints are not as tight in the latter. This is due to the lower gains associated with enforcing a much lower debt level when inflation distortions are already smaller. As in the benchmark calibration, combining a revenue ceiling with a primary deficit ceiling yields welfare gains virtually equal to the potential gains. When paired with a liabilities growth limit, the optimal revenue ceiling yields gains that are a bit lower, 14.75%, but still much larger than when imposed by itself.

[24] Debt is currently also far from the postwar average, but did not look significantly different right before the most recent recession, which is not included in the target period for the calibration.

Table F.1: Benchmark calibration and alternative parameterizations

Parameter	Description	Benchmark	Big Government	Low Inflation
α	night market labor disutility	8.9790	8.9790	7.4042
β	discount factor	0.9452	0.9452	0.9615
σ	curvature of utility functions	3.7009	3.7009	5.2000
η	measure of day market consumers	0.3776	0.3776	0.2432
ϕ	day market labor disutility	3.7617	3.7617	4.8780
θ	bond liquidity	0.3747	0.3747	0.3289
ω	government benevolence	0.3400	0.2350	0.3900

Normalized parameters: $\gamma = \zeta = 1$.

Table F.2: Non-stochastic steady state statistics for fully discretionary economies

Variable	Statistic	Benchmark	Big Government	Low Inflation
Targeted				
Debt over GDP	$\frac{B(1+\mu)}{Y}$	0.325	0.330	0.325
Inflation rate	π	0.036	0.052	0.020
Nominal interest rate	i	0.058	0.068	0.040
Liquidity spread	$1 + i - \beta^{-1}(1 + \mu)$	0.038	0.045	0.021
Revenue over GDP	ρ	0.180	0.206	0.180
Expenditure over GDP	$\frac{p_c g}{Y}$	0.180	0.210	0.180
Non-targeted				
Nominal debt	B	1.733	1.945	1.040
Real interest rate	r	0.021	0.015	0.020
Primary deficit over GDP	d	0.000	0.004	0.000
Deficit over GDP	D	0.018	0.025	0.013
Potential welfare gains		10.10%	76.22%	17.40%

Table F.3: Optimal fiscal rules—Alternative calibrations

Constraint	Benchmark		Big Government		Low Inflation	
	Optimal Constraint	Welfare Gain	Optimal Constraint	Welfare Gain	Optimal Constraint	Welfare Gain
Revenue/GDP ceiling	0.151	2.00%	0.130	10.96%	0.151	2.26%
P.deficit/GDP ceiling	−0.007	0.11%	−0.014	0.65%	−0.006	0.09%
Deficit/GDP ceiling	0.005	0.07%	−0.007	0.43%	0.002	0.06%
Debt/GDP limit	0.272	0.02%	0.275	0.08%	0.319	0.02%
Debt ceiling	1.212	0.03%	1.286	0.14%	0.973	0.03%
Liabilities growth limit	0.013	0.06%	−0.002	0.33%	0.005	0.05%
Revenue/GDP ceiling plus						
P.deficit/GDP ceiling	0.148	10.01%	0.144	74.48%	0.148	17.28%
Liabilities growth limit	0.142	8.38%	0.135	61.37%	0.142	14.75%
Expenditure/GDP ceiling	0.148	10.06%	0.141	76.22%	0.145	17.40%

Note: When combining rules, the revenue ceiling is chosen optimally, while the primary deficit ceiling or the liabilities growth limit are set equal to their respective discretionary steady-state (pre-reform) values.