

How to Starve the Beast: Fiscal and Monetary Policy Rules

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Abstract

Societies have come to rely on simple rules to restrict the size and behavior of governments: constraints on monetary policy, revenue, budget balance and debt. I study the merit of these constraints in a dynamic stochastic model in which fiscal and monetary policies are jointly determined. Under several specifications, a revenue ceiling is the only rule that effectively induces the government to lower spending and dominates other policy constraints in terms of welfare by an order of magnitude. However, the reduction in spending is modest and comes at the cost of higher debt and inflation. Monetary policy rules are not desirable as they severely hinder distortion-smoothing and may lead to large welfare losses if implemented incorrectly. Budget balance and debt rules are generally benign, with the former being always preferable to the latter. All types of fiscal rules are usually best implemented at all times, but can be suspended in adverse times, often at a minor cost.

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1 Introduction

Rulers do not often govern in the best interest of their subjects. Among other things, they may spend excessively or improperly, and they may succumb to political expediency and deviate from preestablished policy norms. Direct control of government actions by private agents is probably both unwise and impractical. Aware of these issues, societies have increasingly come to rely on institutions that constrain, rather than dictate, government actions. These constraints usually take form of simple rules, such as an inflation target or a debt ceiling.

Policy rules mix elements of Pigouvian and Hobbesian views of public finance.¹ The former is concerned with how to optimally finance the provision of public goods, while the latter advocates making the tax base inefficient to curb the *Leviathan*. Policy 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 also affect how governments are financed and may better align the policy-mix with the preferences of the governed.

This paper provides a systematic study of institutional constraints on government policy. Taking the view that governments are naturally discretionary and prone to excessive spending, I study the effects of the types of policy rules that we see implemented in the real world to discipline government actions. Specifically, I consider inflation targets, interest rate pegs, Taylor rules, revenue ceilings, limits on the primary or total deficit, and limits on the public debt, either nominal or in terms of output. The main purpose is to understand their effectiveness at curbing government spending and the welfare implications for private agents.

To this end, I consider a model where fiscal and monetary policy are jointly determined. The environment is a monetary economy populated by infinitely-lived agents, where a government uses distortionary taxes, money and nominal bonds to finance the provision of a valued public good.² 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. The economy is potentially subjected to a variety of aggregate shocks to demand, productivity, public expenditure and liquidity.

Under full discretion, government policy is determined by the interaction of three main forces: distortion-smoothing, a time-consistency problem and political frictions. 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.

An important theoretical result is that in the absence of aggregate uncertainty, the discretionary steady state is constrained-efficient. That is, endowing the government with commitment power *at* the steady state would not affect equilibrium policy. In this case, all the welfare gains from imposing policy rules would arise from correcting the political friction, by inducing a reduction in government spending or, at least, altering the means by which expenditure is financed. The key to an effective policy rule is to make the government internalize the cost

¹See Brennan and Buchanan (1977) and Engerer (1990).

²The model is an extension of Martin (2011, 2013), where the monetary economy is based on Lagos and Wright (2005). 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. They common critical element in all these variants is that prices depend on the supply of money.

of socially suboptimal policy. The addition of aggregate uncertainty does not alter this result significantly, as even discretionary governments respond to shocks with sufficient efficiency. In contrast, adopting rules far away from the steady state may significantly alter the prescription, as the time-consistency problem becomes more prominent.

The merits of the various policy rules are evaluated quantitatively, 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 lower inflation. I study both economies with and without aggregate uncertainty. Shocks are assumed to be large and rare, but I also consider more frequent shocks. The lessons drawn are common across all these different specifications, unless otherwise noted.

The main lesson is that the best policy rule is a ceiling on revenue in terms of output. The optimal revenue ceiling is about 15% of GDP, three percentage points lower than for the case of a discretionary government. A revenue ceiling is the only rule that significantly lowers government expenditure; all other rules are ineffective in this regard and only manage to alter the policy-mix by which expenditure is financed. Imposing the optimal revenue ceiling implies sizable welfare gains for private agents, equivalent to about 2% of consumption. Welfare gains for all other rules are at most an order of magnitude lower. Though beneficial to private agents, revenue ceilings imply a deterioration of macroeconomic performance: debt and inflation increase significantly and output contracts. This poses a political challenge to its effective implementation.

Monetary policy rules are not generally desirable as they yield small welfare gains and sometimes even losses relative to full discretion. More problematic is the fact that slight mis-targeting or incorrect timing can lead to large welfare losses. The reason for these negative results is that monetary policy targets hinder the ability of governments to smooth distortions across states. In effect, inflation allows for less distortionary repayments of temporary debt increases.

Budget balance (deficit) and debt rules are generally benign, even though they do not offer as large welfare gains as revenue ceilings and are ineffective at curbing government spending. Budget balance rules, limits on the primary deficit in particular, always yield higher welfare than debt rules. This suggests that the typical focus of government reformers on debt ceilings may be misplaced. It is always more desirable, and arguably easier in practice, to aim at constraining the deficit.

For fiscal rules in general, most welfare gains come primarily from imposing constraints in normal times, which also helps discipline government policy during abnormal times. The cost of suspending fiscal rules during adverse times (e.g., a recession) are minor, as long as these rules are reimposed when the economy returns to normal. In addition, the cost of implementing fiscal rules sub-optimally, e.g., picking the wrong ceiling, also carry relatively small welfare costs. Notable exceptions to these results include suspending budget balance or revenue rules when government expenditure temporarily increases (assuming agents do not value such an increase) and imposing a primary deficit ceiling when debt is well below the steady state.

Rules in practice

Starting around the 1990s, there has been widespread adoption of numerical fiscal rules, in both advanced and emerging economies. According to the IMF Fiscal Rules Dataset, in 2015, 92 out of 96 countries had adopted at least one fiscal rule. Following Schaechter et al. (2012) 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.” These fiscal rules are classified according to the type of variable they attempt to constrain—e.g., deficit, revenue or debt.

Perhaps the most famous examples of fiscal rules are the economic convergence criteria by

prospective members of the European Economic and Monetary Union (the “Eurozone”), which allowed several countries to impose discipline on their governments by targeting policies more in line with those of strong performing economies. The U.S. itself has several formal constraints on fiscal policy. The debt ceiling legislation forces the executive to seek Congressional approval when increasing debt beyond the pre-established limit. In addition, most states are subjected to balanced-budget rules and there have been repeated proposals to impose one at the Federal level.

Countries also adopt formal monetary policy rules and there several examples of this. Australia, Canada, New Zealand, Sweden and the U.K., among many others, have adopted inflation-targeting regimes. Although the specific implementation varies somewhat across countries, there is widespread agreement that inflation targets have been successful in keeping inflation low and stable.³ The convergence criteria for Eurozone membership included explicit inflation and interest rate goals, which were arguably effective.⁴ Perhaps more applicable to developing countries, currency substitution is a simple and effective way to adopt the monetary policy of a more disciplined country.⁵ At the moment, there are several countries exclusively using foreign currency; e.g., Ecuador, El Salvador and Panama all use the U.S. dollar.

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). More recently, around 2014–2015, even core countries such as France were not satisfying European Union deficit targets. In the U.K., inflation was allowed to grow above its target band as a response to the deep recession and elevated unemployment levels that followed the 2007-08 financial crisis. In the U.S., the debt ceiling has done very little to curtail the recent growth of public debt, which has reached levels not seen since the end of World War II.

There is a natural tension between the desirability of constraining government behavior in normal and abnormal times. As wise as it may be to discipline policymakers, severe adverse shocks may require some degree of flexibility, in particular, the relaxation or outright abandonment of pre-existing rules. For example, the U.S. government arguably responded in a discretionary manner during the American Civil War and the two World Wars, but it would likely have been detrimental to limit its capacity to issue debt during these episodes.⁶ More recently, some countries in the Eurozone have questioned the benefits of delegating monetary policy to a supranational entity that does not internalize regional concerns and pondered the desirability of abandoning the monetary union. In all these cases it is hard to separate the value of flexibility from the gains of political expediency.

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 Un-

³See Mishkin (1999) and Svensson (1999) for analyses of the international experience with inflation targeting and its comparison to other, less formally institutionalized, monetary policy regimes.

⁴See Martin and Waller (2012).

⁵A currency board, such as the one adopted by Argentina (1991-2002), Hong-Kong (since 1983) and Bulgaria (since 1997), is a weaker version of this type of constraint. There are also examples of countries allowing the legal circulation of both domestic and foreign currencies.

⁶See Barro (1979), Ohanian (1997), Aiyagari et al. (2002) and Martin (2012).

⁷See Strotz (1956), Kydland and Prescott (1977), Barro and Gordon (1983), Benhabib and Rustichini (1997), Albanesi et al. (2003), Martin (2010), among many others.

fortunately, 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 classical approach in the literature has been to compare the outcomes under full commitment and full discretion. Here, instead, I focus on comparing full discretion with constrained discretionary policy. Related work on fiscal policy constraints includes Bohn and Inman (1996), Athey et al. (2005), Bassetto and Sargent (2006), Chari and Kehoe (2007), Niepelt (2007), Azzimonti et al. (2016), Halac and Yared (2014), Hatchondo et al. (2017) and Halac and Yared (2018). Related work on inflation targeting includes Mishkin (1999), Svensson (1999) and Martin (2015). The effect of tax cuts have been evaluated by Bohn (1991), Romer and Romer (2009, 2010), Cloyne (2013) and Fuest et al. (2018) among many others.

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 policy rules that may be imposed to constraint government behavior. Section 5 analyzes the optimal implementation of each policy rule in economies without aggregate shocks. Section 6 extends the analysis to stochastic economies and adds the possibility of selectively suspending a rule, depending on the state of the economy. Section 7 concludes.

2 Model

2.1 Environment

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 to 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 in 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.⁸ 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 $\zeta > 0$. 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 $\alpha > 0$.

There is a government that supplies a valued public good g at night. Agents derive utility

⁸See Kocherlakota (1998), Wallace (2001), Shi (2006) and Williamson and Wright (2010), among others.

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. 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

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

where B is the current aggregate bond-money ratio, p_c is the—normalized—market price of the night-good c , 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.

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:

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

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

$$q = \frac{E\left[\frac{x'(\eta\theta' u'_x + (1 - \eta)\phi)}{1 + \theta' B'} \middle| s\right]}{E\left[\frac{x'(\eta u'_x + (1 - \eta)\phi)}{1 + \theta' B'} \middle| s\right]} \quad (4)$$

$$\mu = \frac{\beta(1 + \theta B)}{\phi x} E\left[\frac{x'(\eta u'_x + (1 - \eta)\phi)}{(1 + \theta' B')} \middle| s\right] - 1 \quad (5)$$

$$\tau = 1 - \frac{\alpha}{\zeta \gamma U_c} \quad (6)$$

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 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.

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 and variations in current monetary policy. Similarly, from (6) a higher tax rate τ is equivalent to lower night consumption c .

Using these conditions, we can write the government budget constraint (1) in a monetary

equilibrium as

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

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.

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, implements $\{B', x, c, g\}$ —taking as given expected future policy. Policies implemented by the government in the future affect its current budget constraint. This is reflected by the presence of the future allocation x' in the government budget (implementability) constraint (7), due to the fact that future monetary policy affects the current demand for money and bonds. 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 $x' \equiv \mathcal{X}(B', s')$ be the policy that the current government anticipates will be implemented by future governments. 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 $R(g, 1) = 0$, 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.

The following assumption is needed to ensure 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 $v_g - \alpha/\zeta + R_g = 0$ for all $s \in S$ and let $\hat{g} = \max_s \hat{g}(s)$. Then, $v(g)$ and $R(g, \omega)$ satisfy $v_{gg} + R_{gg} < 0$ for all $g \in [0, \hat{g}]$ and all $\omega \in (0, 1]$.*

Let $\Gamma \equiv [\underline{B}, \overline{B}]$ be the set of possible debt levels, where $\underline{B} < \overline{B}$ are such that they do not constrain government choices. 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 elements to define an equilibrium in this economy.

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

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

subject to

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

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:

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

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

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

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

for all $B \in \Gamma$ and all $s \in S$. See Martin (2011) for an extended analysis of these conditions in the non-stochastic case. 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) .

As shown in Martin (2011, 2015) 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.

Proposition 1 *Assume $S = \{s^*\}$ and 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.*

Proof. After a substitution of variables $1 + \hat{B} \equiv (1 + B)/(1 + \theta B)$, the proof proceeds exactly as in Martin (2015). ■

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

$$Y_t = \frac{(1 + \theta_t B_t)[\eta \phi x_t + \gamma_t U_{c,t}(c_t + g_t)]}{\phi x_t}. \quad (12)$$

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: $P_t \equiv \varsigma_x^* p_{x,t} + \varsigma_c^* p_{c,t}$. Using (2) and (3) we obtain

$$P_t = \frac{(1 + \theta_t B_t)(\varsigma_x^* \phi + \varsigma_c^* \gamma_t U_{c,t})}{\phi x_t}. \quad (13)$$

Let inflation be defined as $\pi_t \equiv P_t(1 + \mu_{t-1})/P_{t-1} - 1$ and expected inflation as $\pi_{t+1}^e \equiv E_t[P_{t+1}](1 + \mu_t)/P_t - 1$. Using (5) and (13) we get

$$\pi_{t+1}^e = \beta E_t \left[\frac{(1 + \theta_{t+1} B_{t+1})(\varsigma_x^* \phi + \varsigma_c^* \gamma_{t+1} U_{c,t+1})}{\phi x_{t+1}(\varsigma_x^* \phi + \varsigma_c^* \gamma_t U_{c,t})} \right] E_t \left[\frac{x_{t+1}(\eta u_{x,t+1} + (1 - \eta)\phi)}{(1 + \theta_{t+1} B_{t+1})} \right] - 1. \quad (14)$$

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

$$i_t = \frac{E_t \left[\frac{x_{t+1}(\eta u_{x,t+1} + (1 - \eta)\phi)}{1 + \theta_{t+1} B_{t+1}} \right]}{E_t \left[\frac{x_{t+1}(\eta \theta_{t+1} u_{x,t+1} + (1 - \eta)\theta_{t+1}\phi)}{1 + \theta_{t+1} B_{t+1}} \right]} - 1. \quad (15)$$

Next, consider fiscal variables. Government expenditure (excluding interest payments) and revenue can be both expressed in terms of GDP as $p_{c,t}g_t/Y_t$ and $p_{c,t}\tau_t(c_t + g_t)/Y_t$, respectively.

The primary deficit is the difference between government expenditure before interest payments and tax revenue. The primary deficit over GDP is then defined as: $d_t \equiv p_{c,t}[g_t - \tau_t(c_t + g_t)]/Y_t$. Using (3), (6) and (12) we obtain

$$d_t = \frac{(\alpha/\zeta_t)(c_t + g_t) - \gamma_t U_{c,t} c_t}{\eta \phi x_t + \gamma_t U_{c,t}(c_t + g_t)}. \quad (16)$$

The total fiscal deficit includes the primary deficit plus interest payments on the debt. The deficit over GDP is defined as: $D_t \equiv d_t + \frac{(1+\mu_t)(1-g_t)B_{t+1}}{Y_t}$. Using (4), (5), (12) and (16) we get

$$D_t = \frac{(\alpha/\zeta_t)(c_t + g_t) - \gamma_t U_{c,t} c_t + \beta \eta B_{t+1} E_t \left[\frac{(1-\theta_{t+1})x_{t+1}(u_{x,t+1}-\phi)}{(1+\theta_{t+1}B_{t+1})} \right]}{\eta \phi x_t + \gamma_t U_{c,t}(c_t + g_t)}. \quad (17)$$

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

$$\frac{(1+\mu_t)B_{t+1}}{Y_t} = \frac{\beta B_{t+1}}{\eta \phi x_t + \gamma_t U_{c,t}(c_t + g_t)} E_t \left[\frac{x_{t+1}(\eta u_{x,t+1} + (1-\eta)\phi)}{(1+\theta_{t+1}B_{t+1})} \right] \quad (18)$$

4.2 Policy rules

The constraints on government behavior or “policy rules” studied in this paper can be categorized in four groups, depending on which type policy variable they target: monetary policy, budget balance, debt and revenue.

Consider first monetary policy rules. An inflation target restricts a government to implement policy so that expected inflation is within a given interval, that is, $\pi_{t+1}^e \in [\underline{\pi}, \bar{\pi}]$, where π_{t+1}^e is defined in (14). Similarly, an interest rate rule restricts policy to be consistent with the nominal interest rate fluctuating within a given interval, that is, $i_t \in [\underline{i}, \bar{i}]$, where i_t is defined in (15). For the purpose of the exercises in this paper, I will focus on strict rules: an inflation target, $\underline{\pi} = \bar{\pi}$ and an interest rate peg, $\underline{i} = \bar{i}$.⁹

Taylor rules, as first proposed by Taylor (1993), are often perceived as describing actual central bank behavior or as benchmarks of how it *should* behave. There has even been a recent push in the U.S. to legislate such a rule. In the present context, we can think of a Taylor rule as another monetary policy rule, disciplining the behavior of the government. Consider the following forward-looking variant of the Taylor rule:

$$1 + i_t = (1 + r^*)(1 + \pi_{t+1}^e)^\varphi (1 + \pi^T)^{-\varphi} \quad (19)$$

where i_t is the nominal interest rate given by (15), π_{t+1}^e is the expected inflation rate given by (14), π^T is the desired target for inflation, r^* is the real interest rate in a non-stochastic steady state (standing-in here for the “natural real rate”) and $\varphi > 0$.¹⁰ By the Fisher equation, $1 + i_t \equiv (1 + \pi_{t+1}^e)(1 + r_t^e)$. Using (14) and (15) and imposing a steady state, we obtain

$$r^* = \frac{\phi}{\beta[\eta \theta^* u_x^* + (1 - \eta \theta^*)\phi]} - 1. \quad (20)$$

Note that if government bonds are illiquid, $\theta^* = 0$, then $r^* = \beta^{-1} - 1$. If monetary policy follows a Taylor rule, then the government is constrained to implement expected inflation and

⁹Allowing for small intervals around a monetary target did not seem to have any measurable impact on the results. Ceilings or floors proved to be worse than strict rules and hence omitted from the exercises presented here.

¹⁰I omit a response of the interest rate to the output gap since prices here are flexible.

the nominal interest rate in a way consistent with (19). If we take the parameter φ as given (say, at the standard value of 1.5 used in the New-Keynesian literature), then the choice of the optimal Taylor-rule constraint involves a choice of π^T .

Budget balance rules are constraints to the primary or total deficit. Consider ceilings on the primary deficit $\bar{d}$ and the total deficit $\bar{D}$, 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).

There are two commonly-used versions 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, the latter constraint should be interpreted as a limit on the nominal stock of debt.

Finally, revenue rules are ceilings on tax revenue. The rule analyzed below does not allow revenue over GDP to exceed a legislated ceiling: $p_{c,t}\tau_t(c_t + g_t)/Y_t \leq \bar{\rho}$. Note that revenue rules are not the same as limits on tax rates. The latter would simply target τ_t which by (6) is equivalent to determining night-good consumption, c_t . However, as it turns out, the performance of either type of constraint is very similar.

Different types of policy constraints differ in how they restrict government actions. Compare, for example, an inflation target with a primary deficit ceiling: as we can see from (14) and (16), both constraints depend on $\{x_t, c_t, g_t, s_t\}$, but the inflation target also depends on the choice of debt, B_{t+1} and the expected realization of future allocations, $\{x_{t+1}, c_{t+1}\}$. Thus, the inflation target is intrinsically dynamic while the primary deficit ceiling is static. The debt ceiling, on the other hand, simply restricts the maximum amount of debt that can be accumulated, regardless of allocations. Note that none of the policy constraints depend directly on the inherited level of debt, B_t . However, they all interact with inherited debt through the budget constraint, (7).

Constraints 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, during a deep recession). Alternatively, this may be precisely the time when government behavior *ought* to be restricted. I will consider all these possible cases in the analysis below.

Let us now include the policy constraints in the recursive formulation of the government's problem. Let $j = \{1, \dots, \bar{j}, \dots, J\}$ index the type of constraint, where 1 to $\bar{j}$ are equality constraints and $\bar{j} + 1$ to J are inequality constraints. The indicator function $\mathcal{I}^j(s)$ states whether a constraint of type j is in effect in state s . Constraints on policy can be written then as

$$\mathcal{I}^j(s)\Psi^j(B', x, c, g, s; \mathcal{X}, \mathcal{C}) \leq \psi_j \quad (= 0 \text{ if } j = \{1, \dots, \bar{j}\}) \quad (21)$$

The function Ψ^j corresponds to each of the constraints described above, in a given Markov-perfect equilibrium; ψ_j is the j -th element of the constraint vector ψ and corresponds to the value by which a particular policy variable is constrained (e.g., a primary deficit ceiling).

In general, constraints depend on the current policy choice (B', x, c, g) , the current state s and expected future policy choices $\mathcal{X}(B', s')$ and $\mathcal{C}(B', s')$. Some constraints depend trivially on some of the arguments. For example, an interest rate target only depends non-trivially on B' , s and $\mathcal{X}(B', s')$, while a nominal debt ceiling only depends non-trivially on B' . The problem of the government and the definition of a MPME can be written similarly to the unconstrained case, but with the addition of (21) for all $B \in \Gamma$ and $s \in S$.

As mentioned above, monetary policy constraints, e.g., an inflation target $\bar{\pi}$, an interest rate peg $\bar{i}$ and a Taylor rule with inflation target π^T are equality constraints, while fiscal policy constraints, e.g., a primary deficit ceiling $\bar{d}$, a total deficit ceiling $\bar{D}$, a debt over GDP ceiling $\bar{b}$ and a nominal debt limit $\bar{B}$ are inequality constraints. If we consider these seven constraints,

then $\bar{j} = 3$, $J = 8$ and the constraint vector is defined as $\psi \equiv \{\bar{\pi}, \bar{i}, \pi^T, \bar{d}, \bar{D}, \bar{b}, \bar{B}, \bar{\rho}\}$.

4.3 Static vs dynamic constraints?

Primary deficit rules and revenue ceilings are the only one in the set of policy constraints considered here that do not depend on B' , either directly or indirectly through future policies $\mathcal{X}$ or $\mathcal{C}$. Why is this important? Lack of dependence on B' implies that the Generalized Euler Equation (8) is left functionally intact after adding constraint (21) to the government's problem. This is not the case for any of the other policy constraints. Condition (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 (21) 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 carries an important welfare cost to agents.

Ceilings on the primary deficit or revenue only affect equations (9)–(11). The added term in each condition is the Lagrange multiplier associated with constraint (21) times the marginal change of the constraint with respect to the relevant variable (x , c , or g , respectively). Hence, this type of constraint will alter the way the government views the intratemporal trade-offs between monetary policy, taxation and expenditure. The key to an effective constraint is to make the government internalize the cost of excessive spending by making the static distortions more costly, as captured by the additional terms in (9)–(11). Constraints on the the primary deficit and revenue achieve this without affecting the dynamic policy trade-offs in (8).

4.4 Alternative implementations

As described above, constraints on government policy are imposed in terms of observable policy variables (inflation, deficit, etc). Alternatively, one could restrict government actions by placing constraint on allocations. For example, in an economy without aggregate shocks, a specific inflation rate could be achieved by imposing a particular day-good allocation x . Suppose we restrict the government to conduct policy such that it implements $x = \bar{x}$. Since now $\mathcal{X}_B = 0$, the system (7)–(11) implies $B = B'$ (since now $\lambda = \Lambda'$ —see Martin, 2015 for derivation details) and hence, from (14) we get $\pi_{t+1} \equiv \beta(\eta\bar{u}_x/\phi + 1 - \eta) - 1 = \bar{\pi}$. In other words, there is a one-to-one mapping between $\bar{x}$ and $\bar{\pi}$. A constraint $x = \bar{x}$ and the assumption that future governments also set $x' = \bar{x}$ is a very different object than constraint $j = 1$ considered here, $\pi_{t+1}^e = \bar{\pi}$, which in the non-stochastic case takes the form: $\pi_{t+1} \equiv \frac{\beta(\varsigma_x^* \phi + \varsigma_c^* U_{c,t+1})(\eta u_{x,t+1}/\phi + 1 - \eta)}{\varsigma_x^* \phi + \varsigma_c^* U_{c,t}} - 1 = \bar{\pi}$. This constraint depends on the current choice for c_t , but also on x_{t+1} and c_{t+1} which the current government cannot directly control. Since in equilibrium, $x_{t+1} = \mathcal{X}(B_{t+1})$ and $c_{t+1} = \mathcal{C}(B_{t+1})$, the way a government facing constraint (14) can comply is by appropriately choosing B_{t+1} and c_t (i.e., debt and taxes), rather than directly through the implementation of a day-good allocation x_t .

Note that both of the approaches described above would successfully implement the same inflation target. The sources of the different implementation are the limited commitment friction and the presence of debt, which is an endogenous state variable. The current government is best-responding to future policy. In turn, future policy may itself be restricted, due to a policy constraint; but the shape of the policy function is an equilibrium outcome and not a constraint on the current government.

The above example has important implications. In general, similar policy outcomes could in principle be achieved by placing restrictions on allocations. This approach could even be

desirable from a welfare perspective.¹¹ Consistent with the objective of evaluating real-world constraints, and to keep the paper focused, I here take the stand that policy constraints take the form of constraints on observed policy variables instead of allocations. The fact that we can write these problems in terms of allocations rather than policy variables is solely for analytical convenience.

5 Optimal rules in non-stochastic economies

I first explore the optimality of policy constraints in the absence of shocks. It is important to note that the lessons learned here will carry over to the stochastic case.

5.1 Calibration

Consider the following functional forms: $u(x) = \frac{x^{1-\sigma}-1}{1-\sigma}$; $U(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$; $v(g) = \ln g$; 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.

The non-stochastic version of the economy is calibrated to the post-war, pre-Great Recession U.S., 1955–2008. Government in the model corresponds to the federal government and period length is set to a fiscal year. The variables targeted in the calibration are: debt over GDP, inflation, nominal interest rate, outlays (not including interest payments) over GDP and revenues over GDP. All variables are taken from the Congressional Budget Office. Government debt is defined as debt held by the public, excluding holdings by the Federal Reserve system.

Calibrating the extent of political frictions is more challenging. In principle, one would like to have an estimate of the socially optimal level of government expenditure. Such an estimate is of course hard, if not impossible, to come by. Instead, I use an indirect approach by assuming 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 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 and another one which shares all the same parameter values, except for $\omega = 1$, and that implements 2% inflation in steady state. Parameters values are chosen to match calibration targets exactly—see Tables 1 and 2. For robustness, I also consider two alternative calibrations, as described below: one with a less benevolent (i.e., bigger) government and one with lower inflation.

Table 2 displays steady state statistics for selected economies with a full discretionary government. As we can see, expenditure over GDP in the benevolent economy is about 3 percentage points lower than in the benchmark economy: 14.8% of GDP vs 18.0%. The size of the benevolent government would thus be similar to the actual U.S. federal government around the mid-1950s. Table 2 presents both targeted and non-targeted moments, as a reference for the exercises conducted below.

5.2 Optimal policy constraints

Each type of constraint on policy is imposed at 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.

¹¹One can show numerically that this is indeed the case for an inflation target.

Table 1: Benchmark Calibration

α	β	σ	η	ϕ	θ	ω
8.9790	0.9452	3.7009	0.3776	3.7617	0.3747	0.3400

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

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

Variable	Statistic	Benchmark	Benevolent	Big Government	Low Inflation
<i>Targeted</i>					
Debt over GDP	$\frac{B(1+\mu)}{Y}$	0.325	0.319	0.330	0.325
Inflation rate	π	0.036	0.020	0.052	0.020
Nominal interest rate	i	0.058	0.048	0.068	0.040
Revenue over GDP	ρ	0.180	0.152	0.206	0.180
Expenditure over GDP	$\frac{p_{cg}}{Y}$	0.180	0.148	0.210	0.180
<i>Non-targeted</i>					
Nominal debt	B	1.733	1.542	1.945	1.040
Real interest rate	r	0.021	0.028	0.015	0.020
Primary deficit over GDP	d	0.000	-0.004	0.004	0.000
Deficit over GDP	D	0.018	0.001	0.025	0.013

Note: “Benchmark” targets the postwar US economy using the parameterization from Table 1; “Benevolent” sets $\omega = 1$; “Big Government” sets $\omega = 0.235$; “Low Inflation” recalibrates the economy to 2% annual inflation: $\alpha = 7.4042$, $\beta = 0.9615$, $\sigma = 5.2000$, $\eta = 0.2432$, $\phi = 4.8780$, $\theta = 0.3289$ and $\omega = 0.3900$.

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 , $j = \{1, \dots, J\}$, 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, i.e., “starving the beast”; and altering the policy mix, i.e., changing which margins get distorted.¹² 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.

¹²Although the phrase “starving the beast” may more commonly be used for limiting spending by cutting

As a reference, Table 3 presents the welfare gains to private agents from making the government fully benevolent, evaluated at the discretionary, non-benevolent steady state (which, of course, differs across parameterizations). For the benchmark calibration, the welfare gains derived from making the government benevolent are equivalent to 10% of consumption; these gains are 76% for the “big government” case and 17% for the “low inflation” calibration. Clearly, the potential welfare gains from institutional reform are large in all cases considered.

Table 3: Welfare gains from government becoming benevolent

Benchmark	Big Government	Low Inflation
10%	76%	17%

Table 4 presents results at the optimal values of each policy constraint, for the case of the non-stochastic benchmark economy. 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.

Table 4: Optimal constraints and steady state statistics—benchmark calibration

Variable / Constraint	Monetary policy rules			Budget balance rules		Debt rules		Revenue ceiling
	Inflation target $\bar{\pi}$	Interest rate peg $\bar{i}$	Taylor rule π^T	P. deficit ceiling $\bar{d}$	Deficit ceiling $\bar{D}$	Debt over GDP limit $\bar{b}$	Debt ceiling $\bar{B}$	
Optimal constraint	0.040	0.055	0.051	−0.006	0.005	0.274	1.270	0.151
Welfare gains	0.00%	0.02%	0.01%	0.11%	0.07%	0.02%	0.03%	2.00%
Steady State	−0.12%	0.20%	−0.48%	0.25%	0.73%	0.26%	0.31%	1.29%
Transition	0.13%	−0.17%	0.49%	−0.14%	−0.66%	−0.24%	−0.27%	0.71%
<i>Steady state statistics</i>								
Debt over GDP	0.355	0.284	0.442	0.285	0.166	0.271	0.260	0.477
Inflation rate	0.040	0.032	0.051	0.012	0.012	0.030	0.029	0.119
Nominal interest rate	0.060	0.055	0.067	0.043	0.043	0.054	0.054	0.108
Revenue over GDP	0.180	0.180	0.179	0.186	0.182	0.180	0.180	0.151
Expenditure over GDP	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.172
Nominal debt	2.001	1.405	3.020	1.443	0.681	1.311	1.232	3.089
Real interest rate	0.020	0.023	0.015	0.031	0.031	0.024	0.024	−0.010
Primary deficit over GDP	0.000	0.000	0.001	−0.006	−0.002	0.000	0.000	0.021
Deficit over GDP	0.020	0.015	0.028	0.006	0.005	0.014	0.013	0.067

All types of constraints are effective in increasing agents’ welfare: gains range from a maximum of 2% for the case of a revenue ceiling to a minimum of essentially zero for the case of an inflation target. Fiscal rules are more beneficial than monetary rules: the revenue ceiling performs the best, followed by budget balance rules. Debt limits/ceilings appear less desirable than deficit rules and monetary policy rules are even less desirable. The best rule, the revenue ceiling, achieves only a fifth of the potential welfare gains: 2% vs 10%. All these results will recur throughout the exercises conducted below.

taxes, I use it here in a more general sense to include any mechanism that constraints government actions to curb spending.

It is interesting to compare the welfare gains from imposing monetary policy rules with the results obtained in Martin (2015).¹³ In that paper, two policy reforms were considered: making the monetary authority fully benevolent and adopting an inflation target. One critical difference is that the inflation target in Martin (2015) is implemented directly through allocations rather than through a constraint on π_{t+1} , as it is modeled here; the former approach removes the strategic interactions between the inflation target and fiscal policy, whereas the latter does not—see the previous discussion on alternative implementations. The welfare gains found in Martin (2015) were 0.01% of consumption from making the central bank fully benevolent and 0.06% of consumption from adopting an (optimal) inflation target of 1.6% annual. Here, the optimal inflation target is much higher, 4% annual, and yields a welfare gain in between those previous estimates: 0.03% of consumption. However, there are better types of constraints on monetary policy. Adopting an interest rate peg of 5.5% annual implies a welfare gain equivalent to 0.17% of consumption, while a Taylor rule with an inflation target of 5.1% yields a gain equivalent to 0.13% of consumption.

Constraints on fiscal policy can yield much larger gains than constraints on monetary policy, potentially up to two orders of magnitudes larger. The best constraint is a revenue ceiling, in the benchmark calibration, 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. As analyzed in section 4.3, limits on the primary deficit and revenue are different 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.

Table 4 also shows the steady state statistics of constrained economies. A comparison with the benchmark economy (Table 2) sheds some light on the effectiveness of policy constraints. First, only the revenue ceiling manages to curb government spending, and then only modestly: steady state g drops by about 5% or 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.¹⁴ 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 government avoids lowering expenditure too much, given the revenue limit.

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 bias. Interestingly, constraints that yield the highest welfare gains are those that implement (indirectly) low inflation. 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 Taylor rule with an inflation target of 5.1% annual leads to a significant debt build up, which reaches 44.2% of GDP, about 10 percentage points higher than benchmark. In contrast, a deficit ceiling of half a percent of output leads to a severe contraction in debt over GDP, about half of benchmark.

¹³The model economy in Martin (2015) is similar to the one studied here, although with some important differences. The economy is also calibrated to the postwar U.S. and the degree of government non-benevolence is essentially the same as the one derived here.

¹⁴Since 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.

The results in Table 4 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 debt over GDP limit or a debt ceiling, but it is more desirable for private agents to achieve this goal through budget balance rules. The revenue ceiling offers the most effective way to curb excessive government spending. 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.

5.3 Transitions

Figures 1–4 track the evolution of macroeconomic and policy variables following the imposition of the constraints analyzed above. Convergence to the new steady state is quite fast for monetary and debt rules, while slower for budget balance and revenue rules. In all cases, government expenditure over GDP has a flat time-profile. In the case of a revenue ceiling, the vast majority of the reduction in spending happens on impact.

The imposition of monetary policy rules has fiscal implications right away. Both an inflation target and a Taylor rule lead to primary deficits and the rapid accumulation of public debt. Along the transition, there is an expansion of output. These rules trade-off gains along the transition with losses across steady states. In contrast, an interest rate peg implies a brief adjustment, involving a primary surplus, lower expected inflation and output below steady state. As mentioned above, the transition is costly and offset by gains in the long-run.

The effects of a ceiling on the primary deficit are felt immediately, with all variables jumping close to the new steady state after the rule is imposed. In contrast, a ceiling on the total deficit implies a protracted transition. On impact, the government runs a large primary surplus, gradually reducing it as debt declines. In both cases, inflation and interest rates are much lower than in the discretionary equilibrium.

Debt rules imply an immediate adjustment to the new limit by running primary surpluses and suffering a loss in output. The transition takes only a few periods, with the vast majority of adjustment occurring in the period of the reform.

The optimal revenue ceiling induces the government to run a large primary deficit. This implies a gradual accumulation of debt and an associated increase in inflation and interest rates. As mentioned above, the bulk of the decline in spending happens on impact, the transition implying a slight further reduction. Real output declines gradually but permanently, due to the reduction in government spending. Note, however, that the reduction in output is lower than the reduction in spending (spending over output declines) since policy distortions are lower.

5.4 Robustness I: timing of reform

A potential concern is the fact that constraints could be imposed at inappropriate times. For example, the calculations for optimal constraints rely on them being implemented at the steady state. What happens when constraints are placed far from this 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 5 provides an answer to this question.

The optimal inflation target can lead to some important welfare losses when implemented far from the steady state. These losses are even bigger when imposing the optimal interest rate target or a Taylor rule. In fact, there is only a small range of debt levels over which monetary policy constraints are welfare improving. A curious result is that the gains from imposing the optimal Taylor rule increase when debt is sufficiently below (but not too much below) the steady

Figure 1: Monetary policy rules—dynamics

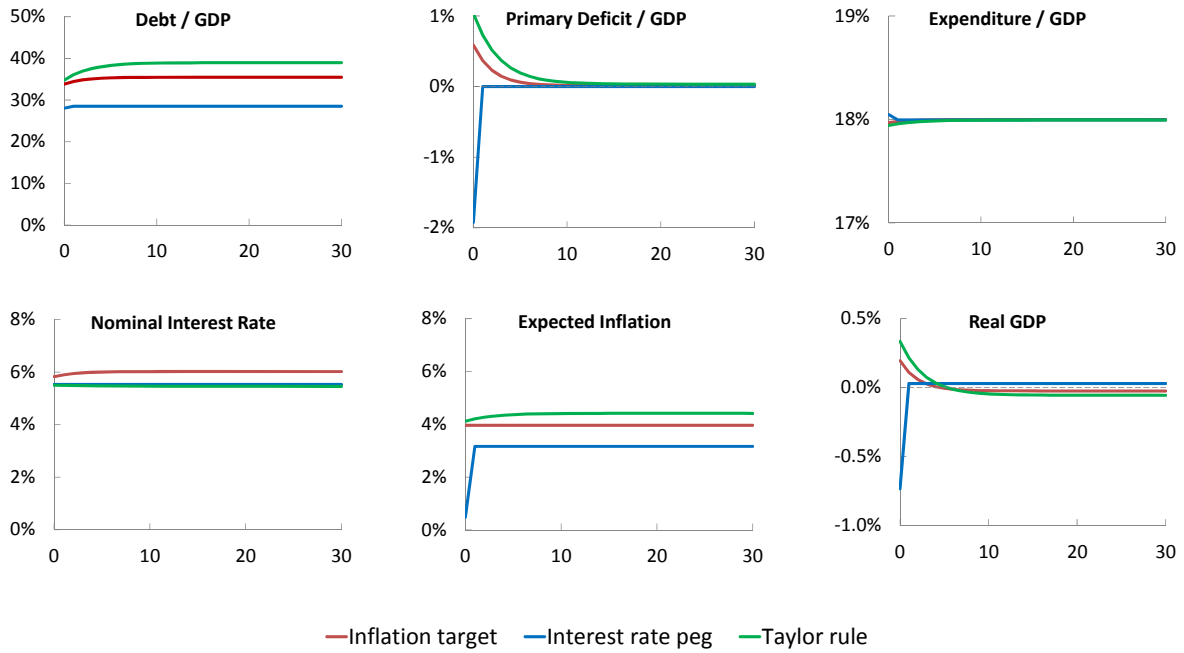


Figure 2: Budget balance rules—dynamics

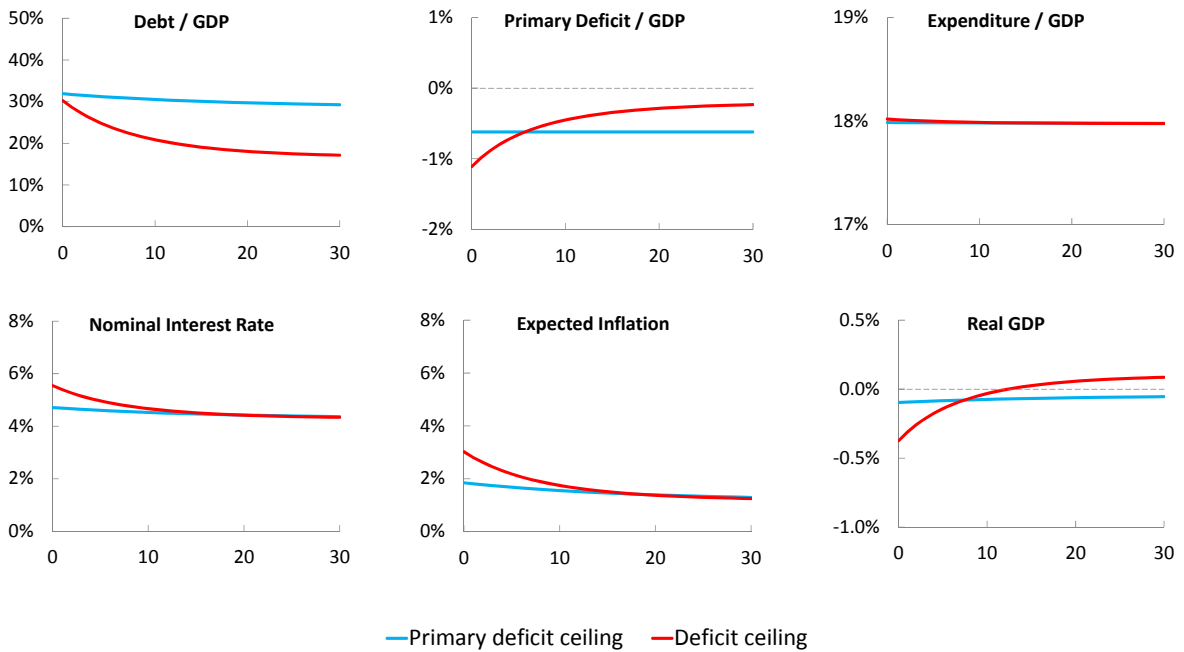


Figure 3: Debt rules—dynamics

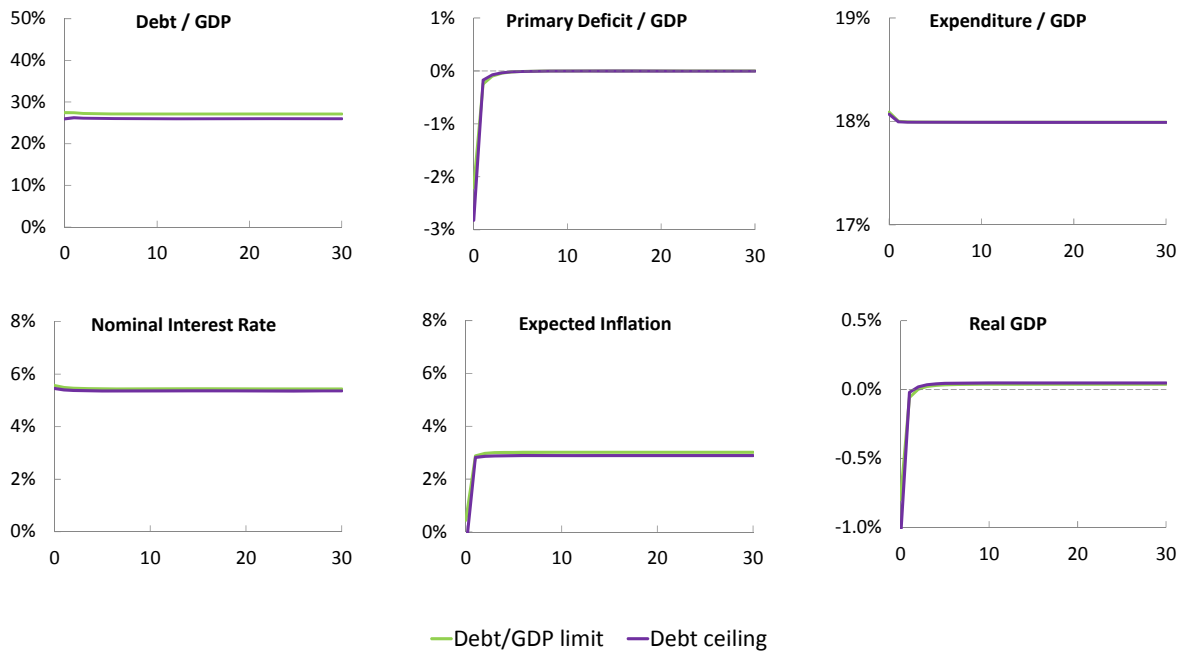


Figure 4: Revenue rules—dynamics

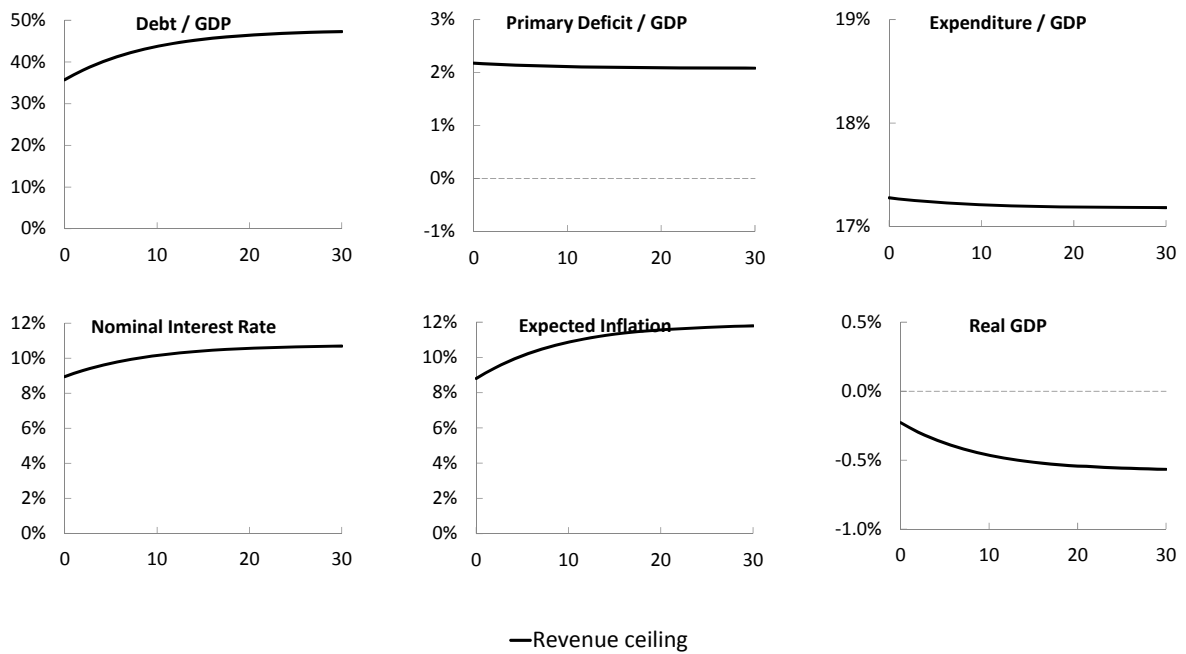
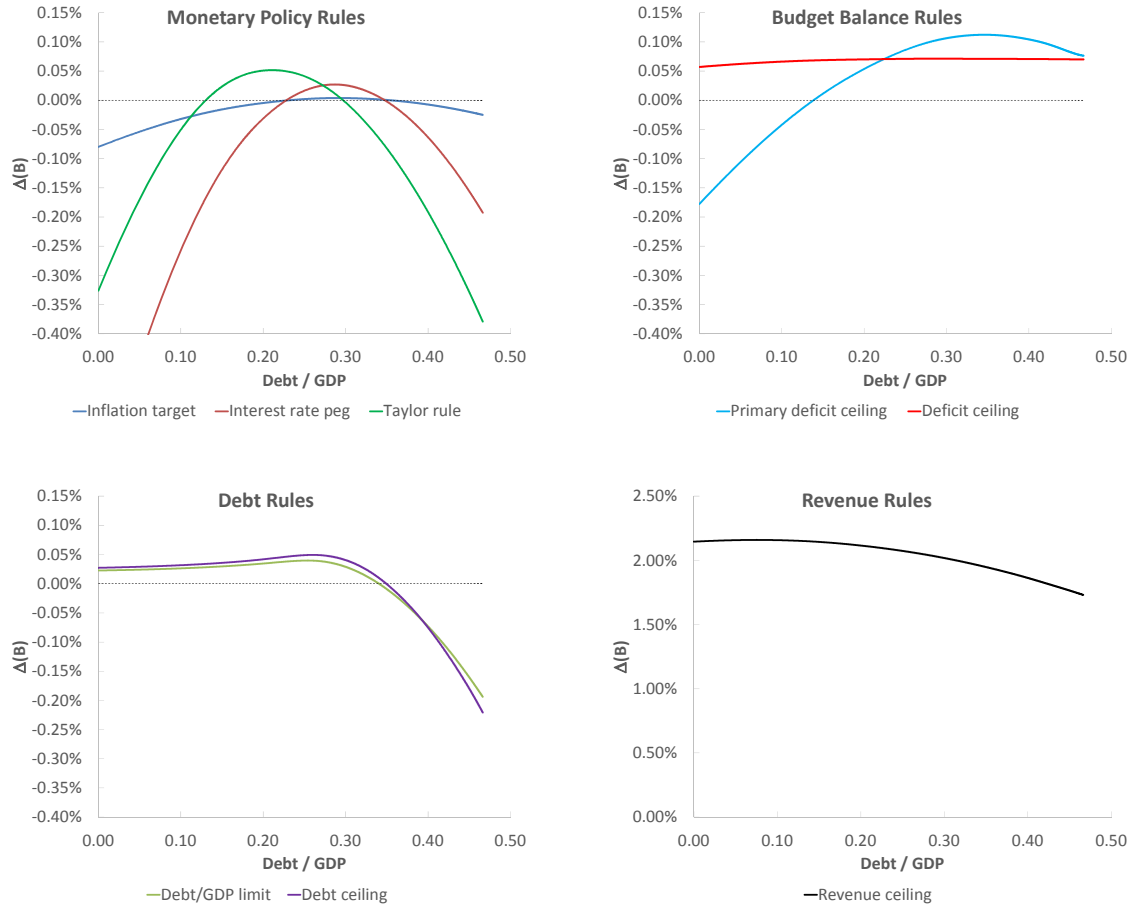


Figure 5: Welfare gains of optimal steady state constraints by initial debt level



state.

The optimal primary deficit target typically leads to fairly consistent welfare gains, even when initial debt is fairly high. The exception is when initial debt is low, as the requirement of a primary deficit surplus severely limits the amount of debt accumulation and thus, mitigates distortion-smoothing. 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. Both debt 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.

The revenue ceiling remains significantly more beneficial than all other constraints, 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 is not only the most effective type of constraint, but also does not require that the imposition of the rule be implemented close to the steady state.

5.5 Robustness II: big government

Consider now the case of an economy with an even less benevolent government. Table 2 shows the steady state statistics of an economy with $\omega = 0.235$. 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.

Table 5: Optimal constraints—alternative calibrations

Constraint	Benchmark		Big Government		Low Inflation	
	Optimal Constraint	Welfare Gain	Optimal Constraint	Welfare Gain	Optimal Constraint	Welfare Gain
Inflation target	0.040	0.00%	0.060	0.02%	0.024	0.01%
Interest rate peg	0.055	0.02%	0.060	0.12%	0.037	0.06%
Taylor rule	0.051	0.01%	0.088	0.08%	0.032	0.02%
Primary deficit ceiling	−0.006	0.11%	−0.013	0.67%	−0.006	0.09%
Deficit ceiling	0.005	0.07%	−0.007	0.44%	0.002	0.06%
Debt over GDP limit	0.274	0.02%	0.260	0.08%	0.274	0.07%
Debt ceiling	1.270	0.03%	1.335	0.15%	0.798	0.08%
Revenue ceiling	0.151	2.00%	0.129	11.31%	0.151	2.26%

Table 5 presents the optimal constraint for this economy. When compared to the benchmark economy, the optimal constraints are all stricter when facing a less benevolent government, i.e., monetary policy targets are all higher, while fiscal policy limits/ceiling are all lower. Since the potential gains are larger the less benevolent the government, 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.

5.6 Robustness III: low inflation

Arguably, inflation is the one policy variable that in the last two decades looks significantly different from the postwar average.¹⁵ In order to account for this fact and thus deliver recommendations more applicable to the current economy, I consider an alternative calibration that delivers a steady state inflation of 2% annual. Parameters values and steady state statistics are presented in Table 2, along with the other economies studied above. 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. As we can see in Table 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 optimal constraints for the low inflation economy are presented in the last two columns of Table 5. The lessons from the benchmark economy apply to the low inflation economy:

¹⁵Debt 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.

the best constraint is to impose a revenue ceiling (also 15.1% of GDP in this case); budget balance and debt constraints are superior to monetary policy rules; and the best monetary policy constraint is an interest rate peg at 3.7% annual.

One notable difference between the benchmark and low inflation economies is that the welfare gains from imposing budget balance or debt rules are much more compressed in the low inflation economy, although the primary deficit ceiling still delivers higher gains than the alternatives within this group of constraints.

6 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.

6.1 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: $\varpi_{1,1} = \varpi_{3,3} = \varpi$; $\varpi_{1,2} = \varpi_{3,1} = 1 - \varpi$; $\varpi_{1,3} = \varpi_{3,1} = 0$; $\varpi_{2,2} = \varpi^*$; 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). That is, infrequent but painful events that strain the will to maintain rules and instead favor the adoption of more politically 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

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	$\omega(1 + \varrho_\omega)$

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

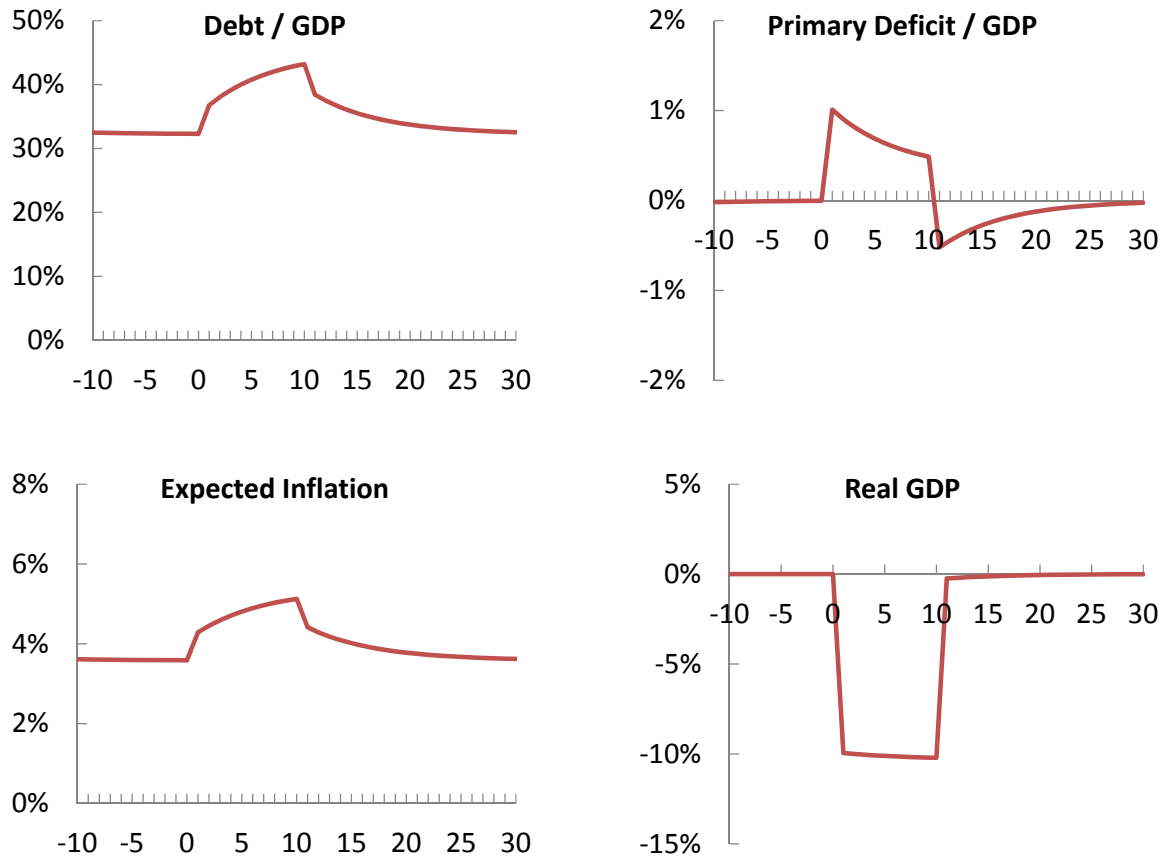
6.2 Optimal policy constraints for demand shocks

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. As a reference, Figure 6 shows the response of a fully discretionary government to a typical demand shock. The drop in output implies a drop in revenue; the government 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 remains elevated after output returns to normal in order to smoothly bring back debt to pre-shock levels.

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 7).

There are several important observations coming out of Table 7. First, placing an upper limit on revenue improves welfare the most. The optimal value is to have a cap on revenue equal to 15.1% of GDP. Notably, this is the same result we obtained in the non-stochastic case. Second, for all types of constraints, the optimal values and welfare gains are remarkably similar to the non-stochastic benchmark economy. Part of the reason is 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. Third, for all types of constraints, most of the welfare gains come from imposing constraints in normal times and suspending constraints during abnormal (both bad and good) implies only small differences in welfare, sometimes positive other times negative. This suggests that welfare gains primordially stem from the reduction in government size and change in the long-run policy mix accomplished with the imposition of constraints, and not from inefficiencies due to how discretionary governments respond to shocks. In this case,

Figure 6: Response of fully discretionary government to typical demand shock



trend considerations trump cyclical ones.

Figure 7 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 constraint 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.

Monetary and fiscal policy constraints differ on when they are best imposed. If monetary policy is to be constrained, then it is best to impose it only during normal times. In contrast, fiscal policy constraints (except the debt over GDP limit and then, only by a tiny margin) are best imposed at all times. The difference in prescription stems from the fact that monetary policy is a useful tool for weathering shocks, as it helps nominal debt become more state-contingent by changing its real value depending on the aggregate state. Fiscal policy constraints do not hinder the government ability to smooth out distortions intertemporally by employing monetary policy. In fact, as analyzed above, a limit on the primary deficit or revenue have no impact on the intertemporal trade-offs faced by the government.

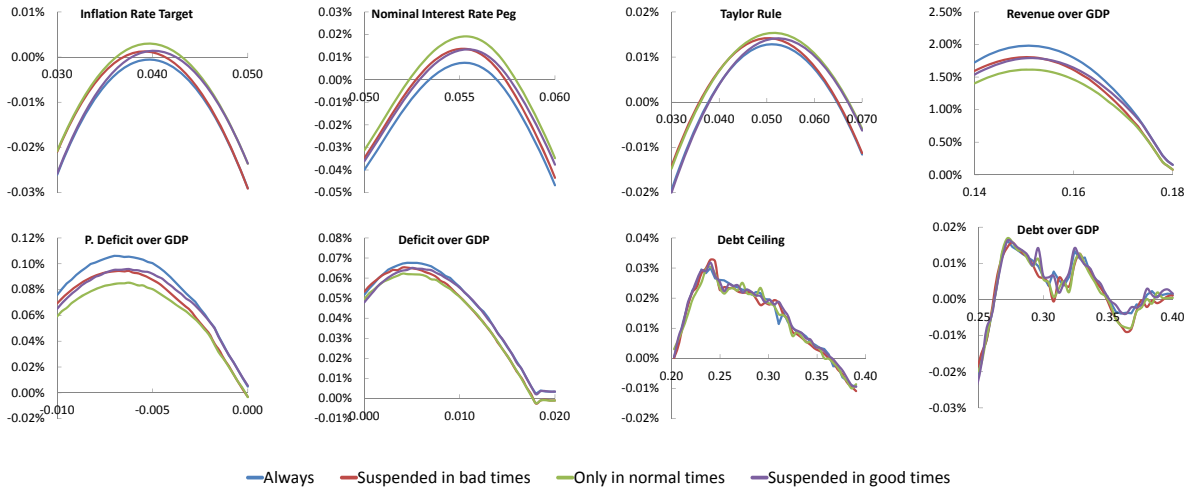
Is it costly to set the wrong value for a constraint? As Figure 7 illustrates, the answer depends on the type of constraint. Budget balance and revenue rules are benign for a significant

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
Inflation target	0.040	0.00%	0.00%	0.00%	0.00%
Interest rate peg	0.055	0.01%	0.01%	0.02%	0.01%
Taylor rule	0.052	0.01%	0.01%	0.02%	0.01%
Primary deficit ceiling	−0.006	0.11%	0.09%	0.08%	0.09%
Deficit ceiling	0.005	0.07%	0.07%	0.06%	0.06%
Debt over GPD limit	0.272	0.02%	0.02%	0.02%	0.02%
Debt ceiling	1.279	0.03%	0.03%	0.03%	0.03%
Revenue ceiling	0.151	1.98%	1.80%	1.61%	1.79%

Note: For each type of policy constraint, “optimal value” corresponds to the best scenario (bolded).

Figure 7: Welfare gains over full discretion



range around the optimum. For example, small primary surpluses and revenue ceilings are always beneficial, so getting the exact value for the constraint right is not critical, which is an added benefit as it reduces the costs of improper implementation. In contrast, monetary policy targets can quickly turn a gain into a substantial loss. Coupled with the fact that the welfare gains of the optimal value are fairly small to begin with, this implies that monetary targets are not desirable constraints.

Debt constraints are good as long as they are not too tight, as they interact with the ability of the government to smooth distortions. A limit on debt over GDP, as the one imposed on Eurozone countries, has the peculiar property of two local maxima. Note however, that the stricter limit yields higher welfare. The welfare gains of a debt ceiling, as the one implemented nominally in the U.S., are single peaked, but note that they rapidly convert into losses when it is set too high. The reason for this result is that too-high debt ceilings do not provide the benefits of lower expenditure, but still hinder tax-smoothing.

6.3 Robustness I: frequent abnormal times

Next we consider increasing the frequency of abnormal times or, equivalently, reducing the duration of normal times. Let $\varpi^* = \varpi = 0.9$; that is, all states have now 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.

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

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Inflation target	0.040	−0.01%	0.00%	0.00%	0.00%
Interest rate peg	0.055	−0.03%	0.00%	0.01%	0.00%
Taylor rule	0.055	0.01%	0.01%	0.02%	0.01%
Primary deficit ceiling	−0.007	0.10%	0.06%	0.04%	0.06%
Deficit ceiling	0.005	0.06%	0.05%	0.04%	0.05%
Debt over GDP limit	0.272	0.01%	0.01%	0.01%	0.01%
Debt ceiling	1.280	0.03%	0.02%	0.02%	0.03%
Revenue ceiling	0.151	1.94%	1.37%	0.84%	1.34%

Note: For each type of policy constraint, “optimal value” corresponds to the best scenario (bolded).

6.4 Robustness II: productivity, liquidity and expenditure shocks

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

Although each case presents its own idiosyncracies, the similarities across economies are notable. For each type of shock the best prescription remains a revenue ceiling of about 15% of GDP. It is always best not to suspend this constraint. Again, even if the constraint is imposed only during normal times, due to the distortion-smoothing motive, it is disciplining government behavior during abnormal times. Except for the case with expenditure shocks, the welfare loss of suspending budget balance and revenue rules during abnormal times (good, bad or both) is very small. The exception arises since spending shocks stem from variations in government benevolence; thus, it becomes important to constraint the government during bad times.

Monetary policy rules remain largely undesirable, leading in certain certain cases to welfare losses relative to full discretion. Their performance is especially poor in the presence of liquidity shocks. When they do improve welfare over discretion, it is in the form of an interest rate target and the gains are small. Debt constraints fare better, especially a debt ceiling that is imposed at all times. Still the gains from debt constraints are dominated by those of budget balance constraints, even when they are not implemented optimally.

6.5 Robustness III: correlated shocks

One possible concern is that government spending may become more valuable to private agents during adverse times. For instance, during recessions a series of policies are implemented (sometimes automatically) to help distribute the burden across agents; extensions to unemployment insurance are a prime example. Though the present environment is not rich enough to model this effects, we can capture some of this mechanism by assuming that the value of public goods increases when the demand for private goods decreases. That is, model demand and (valued) expenditure shocks as being perfectly correlated. Now, whenever there is a demand shock, there is simultaneous change in the valuation of public goods. Let $v(g) = \psi \ln g$, where ψ takes the

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
Inflation target	0.040	−0.02%	−0.01%	0.00%	−0.01%
Interest rate peg	0.055	0.00%	0.01%	0.02%	0.01%
Taylor rule	0.049	−0.02%	0.00%	0.02%	0.00%
Primary deficit ceiling	−0.007	0.11%	0.10%	0.08%	0.09%
Deficit ceiling	0.005	0.07%	0.07%	0.06%	0.06%
Debt over GPD limit	0.272	0.02%	0.02%	0.02%	0.02%
Debt ceiling	1.280	0.03%	0.03%	0.03%	0.03%
Revenue ceiling	0.151	2.01%	1.84%	1.62%	1.77%

Liquidity shocks

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Inflation target	0.040	0.00%	0.00%	0.00%	0.00%
Interest rate peg	0.055	−0.03%	−0.01%	0.01%	−0.03%
Taylor rule	0.051	0.02%	0.02%	0.02%	0.02%
Primary deficit ceiling	−0.006	0.10%	0.10%	0.09%	0.09%
Deficit ceiling	0.005	0.07%	0.07%	0.06%	0.06%
Debt over GPD limit	0.325	0.02%	0.02%	0.01%	0.02%
Debt ceiling	1.516	0.03%	0.03%	0.03%	0.03%
Revenue ceiling	0.151	2.01%	1.84%	1.60%	1.77%

Government expenditure shocks

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times	Suspended in good times
Inflation target	0.040	0.00%	0.00%	0.01%	0.00%
Interest rate peg	0.056	0.02%	0.01%	0.01%	0.02%
Taylor rule	0.050	0.01%	0.02%	0.02%	0.02%
Primary deficit ceiling	−0.007	0.14%	0.08%	0.08%	0.13%
Deficit ceiling	0.004	0.09%	0.06%	0.06%	0.09%
Debt over GPD limit	0.325	0.02%	0.02%	0.02%	0.02%
Debt ceiling	1.517	0.04%	0.04%	0.04%	0.04%
Revenue ceiling	0.151	2.28%	1.76%	1.64%	2.14%

Note: For each type of policy constraint, “optimal value” corresponds to the best scenario (bolded).

value 1 in normal times (as in the benchmark calibration), 1.1 in bad times and 0.9 in good times.

Table 10 presents the results for the case of correlated demand and expenditure shocks. As we can see, the results do not vary significantly from having only demand shocks. One notable exception is that now an interest rate peg seems to perform much better.

Table 10: Welfare gains over full discretion—correlated demand and public expenditure shocks

Constraint	Optimal Value	Always	Suspend in bad	Only in normal	Suspend in good
Inflation target	0.040	−0.01%	−0.01%	0.00%	−0.01%
Interest rate peg	0.052	0.01%	0.04%	0.05%	0.03%
Taylor rule	0.051	0.00%	0.01%	0.01%	0.01%
Primary deficit ceiling	−0.007	0.10%	0.09%	0.08%	0.09%
Deficit ceiling	0.004	0.06%	0.06%	0.06%	0.06%
Debt over GDP limit	0.272	0.02%	0.02%	0.02%	0.01%
Debt ceiling	1.280	0.03%	0.03%	0.03%	0.03%
Revenue ceiling	0.151	1.94%	1.76%	1.61%	1.80%

Note: For each type of policy constraint, “optimal value” corresponds to the best scenario (bolded).

7 General Lessons and Conclusions

The exercises presented in this paper offer some important and novel lessons for the institutional design of government policy.

First, imposing ceiling on revenue is always the best policy and it is never optimal to suspend this constraint. For an economy calibrated to the U.S. and subject to a variety of shocks, the optimal revenue ceiling is usually about 15% of GDP. Welfare gains to private agents of imposing the optimal revenue ceiling are sizable, about 2% of consumption. Welfare gains for other rules are at most an order of magnitude lower.

Second, revenue ceilings are the only rule that effectively induces governments to lower spending. The reduction in government size is modest, but significant enough to explain the superior welfare gains derived from imposing revenue ceilings over all other types of constraints. However, the reduction in government size carries a cost in terms of macroeconomic aggregates: higher debt and inflation and lower output.

Third, monetary policy rules, i.e., inflation and interest rate targets, are not generally desirable constraints. Both in economies with and without aggregate fluctuations, monetary policy targets yield small welfare gains and even losses relative to full discretion. More problematic is the fact that slight mis-targeting or incorrect timing can lead to large welfare losses. The reason for these negative results is that monetary policy targets hinder the ability of governments to smooth distortions across states. In effect, inflation allows for less distortionary repayments of temporary debt increases.

Fourth, for fiscal rules in general, most welfare gains come primarily from imposing constraints in normal times, which also helps discipline government policy during abnormal times. Key to this result is a commitment to reimpose rules when the state of the economy is back to normal. The cost of implementing fiscal rules sub-optimally, e.g., picking the wrong ceiling or suspending constraints during abnormal times, carry relatively small welfare costs. Notable exceptions include suspending budget balance or revenue rules when government expenditure temporarily increases (assuming agents do not value such an increase) and imposing a primary deficit ceiling with very low debt.

Fifth, debt limits are generally effective, but are always dominated by budget balance rules, even when these latter constraints are not implemented at their best (e.g., because society allows them to be suspended in bad times). This suggest that the typical focus of government reformers on debt ceilings may be misplaced. It is always more desirable, and arguably easier

in practice, to aim at constraining the deficit.

Last, but not least, the socially effective way to combat inefficiently high public expenditure, is not more pre-commitment to government actions, but rather commitment to rules that constraint government action. The difference is that the latter makes the government internalize the cost of socially suboptimal policy. Rules that affect static margins without affecting intertemporal trade-offs perform better.

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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:

$$\gamma U_c - \frac{\alpha}{(1 - \tau)\zeta} = 0 \quad (22)$$

$$-\frac{\alpha(1 + \mu)}{p_c(1 - \tau)\zeta} + \beta E[V'_m|s] = 0 \quad (23)$$

$$-\frac{\alpha(1 + \mu)q}{p_c(1 - \tau)\zeta} + \beta E[V'_b|s] = 0 \quad (24)$$

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

$$u_x - \frac{\alpha p_x}{p_c(1 - \tau)\zeta} - \xi p_x = 0 \quad (25)$$

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

$$-\phi + \frac{\alpha p_x}{p_c(1 - \tau)\zeta} = 0 \quad (26)$$

Given $V(m, b, B, s) \equiv \eta V^c(m, b, B, s) + (1 - \eta)V^p(m, b, B, s)$ and using (26) we obtain:

$$\begin{aligned} V_m &= \phi/p_x + \eta\xi \\ V_b &= \phi/p_x + \eta\theta\xi \end{aligned}$$

Using these expressions, together with (26), we can rewrite (23) and (24) as

$$1 + \mu = \frac{\beta p_x E[\phi/p'_x + \eta\xi'|s]}{\phi} \quad (27)$$

$$q = \frac{E[\phi/p'_x + \eta\theta'\xi'|s]}{E[\phi/p'_x + \eta\xi'|s]} \quad (28)$$

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,

$$p_x = \frac{1 + \theta B}{x} \quad (29)$$

which gives us (2).

Next, notice that (22) can be rearranged to yield (6):

$$\tau = 1 - \frac{\alpha}{\zeta \gamma U_c} \quad (30)$$

Plugging (29) and (30) into (26) yields (3):

$$p_c = \frac{\gamma U_c(1 + \theta B)}{\phi x} \quad (31)$$

Given (29)–(31) we can solve for the Lagrange multiplier of the liquidity constraint:

$$\xi = \frac{(u_x - \phi)x}{(1 + \theta B)} \quad (32)$$

Hence, (27) and (28) imply, respectively, (5) and (4), i.e.,

$$q = \frac{E\left[\frac{x'(\eta\theta'u'_x + (1 - \eta)\phi)}{1 + \theta'B'} \middle| s\right]}{E\left[\frac{x'(\eta u'_x + (1 - \eta)\phi)}{1 + \theta'B'} \middle| s\right]}, \quad (33)$$

$$\mu = \frac{\beta(1 + \theta B)}{\phi x} E\left[\frac{x'(\eta u'_x + (1 - \eta)\phi)}{(1 + \theta'B')} \middle| s\right] - 1 \quad (34)$$

B Numerical algorithm

Economies without policy constraints are solved globally using a projection method with the following algorithm:

- (i) Let $\Gamma = [\underline{B}, \bar{B}]$ be the debt state space. Define a grid of $N_\Gamma = 10$ points over Γ and set $N_S = 3$. Create the indexed functions $\mathcal{B}^i(B)$, $\mathcal{X}^i(B)$, $\mathcal{C}^i(B)$, and $\mathcal{G}^i(B)$, for $i = \{1, \dots, N_S\}$, and set an initial guess.
- (ii) Construct the following system of equations: for every point in the debt and exogenous state grids, evaluate equations (7)–(11). Since (8) contains $\mathcal{X}^j(\mathcal{B}^i(B))$ (and its derivative) and $\mathcal{G}^j(\mathcal{B}^i(B))$, use cubic splines to interpolate between debt grid points and calculate the derivatives of policy functions.
- (iii) Use a non-linear equations solver to solve the system in (ii). There are $N_\Gamma \times N_S \times 4 = 120$ equations. The unknowns are the values of the policy function at the grid points. In each step of the solver, the associated cubic splines need to be updated so that the interpolated evaluations of future choices are consistent with each new guess.

For economies that include constraints to policy in all or some states, I use value function iteration: solve the maximization problem of the government subject to the corresponding policy constraint, at every grid point. Update the policy and value functions and iterate until convergence is achieved.