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The Value of Constraints on Discretionary Government Policy

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Abstract

This paper investigates how institutional constraints discipline the behavior of discretionary governments and evaluates the welfare properties of such restrictions. The focus is on constraints implemented in actual economies: inflation and interest rate targets, and deficit and debt ceilings. I find that most welfare gains from these restrictions arise when constraining government behavior during normal times, which to a large extent is sufficient to discipline policy in adverse times. It is not optimal to ever suspend constraints when facing expenditure shocks, whereas for other types of shocks, the costs of suspending constraints during abnormal times is minimal. For a variety of aggregate shocks considered, the best policy is to impose a minimum primary surplus of about half a percent of output. The optimal design of policy constraints carries some risk, as choosing the wrong target or an inappropriate implementation time can lead to large welfare losses.

Keywords: time-consistency, discretion, government debt, inflation, deficit, fiscal constraints, inflation targeting, institutional design, political frictions.

JEL classification: E52, E58, E61, E62.

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1 Introduction

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.[1] Unfortunately, the application of benevolent rules may face implementation problems. 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 non-compliance is easy to verify.

Political considerations tend to exacerbate time-inconsistency problems. Policymakers may, for example, be short-sighted due to political turnover, have a desire for "empire-building" or be subjected to patronage. Thus, even in situations where a benevolent planner would not face strong temptations to revise ex-ante optimal plans, there is still a role for constraining the behavior of political actors, which in the end, are the ones actually implementing policy.

Societies have tried to resolve the issues raised above by designing institutions that constrain government policy. There are several illustrative examples of this practice. First, the adoption of economic convergence criteria by prospective members of the European Economic and Monetary Union (the "Eurozone"). This allowed some countries to impose discipline on their governments by targeting polices more in line with those of strong performing economies.[2] Second, many countries, such as Australia, Canada, New Zealand Sweden and the U.K., have adopted inflation targets. 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] Third, the U.S. 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. Fourth, perhaps more applicable to developing countries, currency substitution is a simple and effective way to adopt the monetary policy of a more disciplined country.[4] At the moment, there are several countries exclusively using foreign currency; e.g., Ecuador, El Salvador and Panama 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). As of late 2014 and early 2015, even key countries such as France were not satisfying European Union deficit targets. In the U.K., inflation was allowed 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 arguably done very little to curtail the recent growth of public debt, which has reached levels not seen since the end of World War II.

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

[2] These constraints were very effective in terms of inflation, interest rates and deficits. See Martin and Waller (2012).

[3] See 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.

[4] A 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.

There is a natural tension between the desirability of constraining government behavior in normal and abnormal times. As wise as it may be to impose discipline on 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.[5] 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.

In this paper, I propose a systematic study of institutional constraints on government policy, both in the long-run and in the face of aggregate fluctuations. I take the view that governments are naturally discretionary and study the effects of the types of policy constraints that we see implemented in the real world, as described above, i.e., inflation targets, interest rate rules, limits on deficits and debt ceilings. The purpose is to understand the effectiveness and welfare properties of these constraints.

I consider economies subjected to aggregate fluctuations, such as shocks to aggregate demand, public expenditure, productivity, asset returns and liquidity. The analysis in this paper is guided by several pertinent questions. First, how would a discretionary government behave in such an environment? Second, would placing constraints on the policy response improve welfare? If so, which constraints are more effective? Should we target inflation or nominal interest rates, limit the size of deficits or the level of debt? And what are the optimal levels of such constraints? Third, would it be desirable to suspend rules during adverse times or is it better to impose constraints in all states of the world? Fourth, are mistakes costly? That is, what is the welfare cost of not hitting the correct value for a policy constraint? Fifth, how do these results depend on the likelihood, duration and magnitude of shocks?

To provide answers to the questions posed above, I extend the model of fiscal and monetary policy of Martin (2011, 2013). The environment is a monetary economy based on Lagos and Wright (2005), with the addition of a government that uses distortionary taxes, money and nominal bonds to finance the provision of a valued public good.[6] The government may not be fully benevolent and lacks the ability to commit to policy choices beyond the current period. Under full discretion, government policy is determined by the interaction of three 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 and inflation.

In an economy without uncertainty where the government is non-benevolent, the optimal values for policy constraints are very close to the policies implemented in steady state by a benevolent government (except for the case of debt). For an economy calibrated to the postwar U.S., the best constraint is to impose a minimum primary surplus of 0.8% of output, which yields a welfare gain equivalent to 0.7% of private consumption. Note that the economy without uncertainty is constrained efficient at the steady state. That is, endowing the government with commitment power at the steady state would not affect equilibrium policy. Thus, all the welfare

[5] See Martin (2012), Barro (1979) and Aiyagari et al. (2002).

[6] 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.

gains come from correcting the political frictions stemming from the non-benevolent nature of the government.

When allowing for aggregate fluctuations several lessons arise. First, imposing a small primary surplus, of about half a percent of output, is always the best policy. Second, inflation targets have small (and sometimes detrimental) welfare effects relative to full discretion. Third, the optimal values for fiscal policy constraints are similar for stochastic and non-stochastic economies. Fourth, most welfare gains come from imposing constraints in normal times. In addition, except for public expenditure shocks, the welfare loss from suspending constraints during bad or abnormal times is minimal. Fifth, mistakes can sometimes be costly. Specifically, picking the wrong inflation target may lead to large welfare losses.

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 Brennan and Buchanan (1977), Bohn and Inman (1996), Bassetto and Sargent (2006), Chari and Kehoe (2007), Azzimonti et al. (2010), Barseghyan and Battaglini (2012), Halac and Yared (2012) and Harchondo et al. (2012). Related work on inflation targeting includes Mishkin (1999), Svensson (1999) and Martin (2015).

2 Model

2.1 Environment

The environment extends Martin (2011, 2013), which study a variant of Lagos and Wright (2005). There is a continuum of infinitely-lived agents, which discount the future by factor $\beta \in (0, 1)$. Let s denote the exogenous aggregate state of the economy, which is revealed to all agents at the beginning of each period. Let $E[s'|s]$ be the expected value of s' given s. The set of all possible realizations for the stochastic state is S. Each period, two competitive markets open in sequence: a *day* and a *night* market. All goods produced in this economy are perishable and cannot be stored from one subperiod to the next. There is a unit measure of physical assets in fixed supply ("Lucas trees") that bear $\delta(s) \geq 0$ units of the night good every period. Claims to these assets are exchanged in the night market.

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 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.

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 $\zeta(s)n$ units of output, where $\zeta(s) > 0$ for all $s \in S$. Assuming perfect competition in factor markets, the wage rate is equal to productivity $\zeta(s)$. Utility at night is given by $\gamma(s)U(c) - \alpha n$, where U is twice continuously differentiable, $U_{cc} < 0 < U_c$, $\gamma(s) > 0$ for all $s \in S$, and $\alpha > 0$. Note that preferences for the night good may depend directly on the exogenous aggregate state of the economy.

There is a government that supplies a valued public good g at night. Agents derive utility from the public good according to $v(g)$, where v is twice continuously differentiable, satisfies Inada conditions and $v_{gg} < 0 < v_g$. To finance its expenditure, the government may use proportional labor taxes τ, print fiat money at rate μ and issue one-period nominal bonds, which are redeemable in fiat money. The public good is transformed one-to-one from the night-good. 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.

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 is

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

where B is the current aggregate bond-money ratio, p_c is the—normalized—market price of the night-good c, 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. 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 $V(m, b, a, B, s)$ be the value of entering the day market with (normalized) money balances m, bond balances b and asset claims a, 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 $W(z, a, B, s)$ be the value of entering the night market with total (normalized) nominal balances z and claims a.

In the day market, consumers and producers exchange money for goods at (normalized) price p_x. Let x be the quantity consumed and κ the quantity produced. In addition to cash, consumers can pledge up to a fraction $\theta_b(s) \in [0, 1)$ of their bond holdings to finance their day market expenditures. Thus, government bonds in the day are not perfect substitutes of fiat money and consumers face a liquidity constraint as popularized by Kiyotaki and Moore (2002). The problem of a consumer is

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

subject to $p_x x \leq m + \theta_b(s)b$. The problem of a producer is

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

Let $V(m, b, a, B, s) \equiv \eta V^c(m, b, a, B, s) + (1 - \eta)V^p(m, b, a, B, s)$.

In the night market, consumption goods are exchanged at price p_c and asset claims at price p_a. The problem of an agent at night arriving with net nominal balances z is

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

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

2.3 Monetary equilibrium

The resource constraints in the day and night are, respectively: $\eta x = (1 - \eta)\kappa$ and $c + g = \zeta(s)n + \delta(s)$, where here, with a little abuse of notation, n is aggregate night labor. Given the preference assumption, 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. Due to the linear disutility of night labor, agents at the beginning of the period are indifferent over

lotteries of night labor. The preference specification also implies that all agents make the same portfolio choice. Market clearing at night implies $m' = 1$, $b' = B'$ and $a' = 1$.

After some work (omitted here), we get the following conditions characterizing a monetary equilibrium:

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

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

$$p_a = \frac{\beta(1+\theta_b(s)B)}{\phi x} E\left[\frac{p'_a \phi x'}{1+\theta_b(s')B'} + \gamma(s')\delta(s')U'_c \Big| s\right] \tag{4}$$

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

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

$$q = \frac{E[\frac{x'(\eta\theta_b(s')u'_x + (1-\eta\theta_b(s'))\phi)}{1+\theta_b(s')B'}|s]}{E[\frac{x'(\eta u'_x + (1-\eta)\phi)}{1+\theta_b(s')B'}|s]}, \tag{7}$$

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

$$\left(\gamma(s)U_c - \frac{\alpha}{\zeta(s)}\right)(c-\delta(s)) - \frac{\alpha g}{\zeta(s)} - \frac{\phi x(1+B)}{1+\theta_b(s)B} + \beta E\left[\frac{\phi x'(1+B')}{1+\theta_b(s')B'}\Big| s\right] + \beta\eta E[x'(u'_x - \phi)|s] = 0 \tag{8}$$

for all $s \in S$. Condition (8) is also known as an implementability constraint.

3 Discretionary Policy

3.1 Problem of the government

The literature on optimal 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. Note that from (5), for an expected future day-good allocation (which in equilibrium is a function of debt choice, B' and the exogenous state s'), a higher μ clearly implies a lower 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 is equivalent to lower night consumption.

Assume the government can commit to policy announcements for the current period, but not for policy to be implemented in future periods. In this case, the current government cannot directly control x', which as mentioned above, appear in its budget constraint. Instead, these allocations will depend on the policy implemented by the following government, which in turn, depends on the level of debt it inherits and the state of the economy. Let $x' = \mathcal{X}(B', s')$ be the policy that the current government anticipates will be implemented by future governments.

Let $\mathcal{U}(x, c, g, s) \equiv \eta(u(x) - \phi x) + \gamma(s)U(c) - \alpha(c + g - \delta(s))/\zeta(s) + v(g)$ be the ex-ante period utility of an agent. Following Martin (2015) assume the government is not necessarily

benevolent. Let $\mathcal{R}(g, \omega(s))$ be the government's political rent, which is increasing in public expenditure, g and decreasing in the level of government benevolence, $\omega \in (0, 1]$. This rent is a purely utility benefit, with no direct resource cost.

Taking as given future government policy $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}\}$ the problem of the current government is

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

subject to (8) and given

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

With Lagrange multiplier $\lambda(s)$ associated with the government budget constraint, for all $s \in S$, and equilibrium multiplier function $\Lambda(B, s)$, the first-order conditions of the government's problem imply:

$$E\left[\frac{\phi x'(1-\theta_b(s'))(\lambda(s) - \Lambda(B's'))}{(1+\theta_b(s')B')^2}\Big|s\right]$$

$$+\lambda(s)E\left[\mathcal{X}'_B(s')\left\{\eta(u'_x + u'_{xx}x' - \phi) + \frac{\phi(1+B')}{1+\theta_b(s')B'}\right\}\Big|s\right] = 0 \tag{9}$$

$$\eta(u_x - \phi) - \frac{\lambda(s)(1+B)}{1+\theta_b(s)B} = 0 \tag{10}$$

$$\gamma(s)U_c - \frac{\alpha}{\zeta(s)} + \lambda(s)\left\{\gamma(s)U_c - \frac{\alpha}{\zeta(s)} + \gamma(s)U_{cc}(c - \delta(s))\right\} = 0 \tag{11}$$

$$-\frac{\alpha}{\zeta(s)} + v_g + \mathcal{R}_g(s) - \lambda(s)\frac{\alpha}{\zeta(s)} = 0 \tag{12}$$

for all $s \in S$. See Martin (2011) for an extended analysis of these conditions. A Markov-perfect monetary equilibrium (MPME) is a set of functions $\{\mathcal{B}, \mathcal{X}, \mathcal{C}, \mathcal{G}, \Lambda\}$ that solve (8)–(12) 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 equal to $B^* \equiv \mathcal{B}(B^*, s^*)$. 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. See 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 inefficiency in this economy stems from the political friction (i.e., the misalignment in preferences between agents and government). With aggregate fluctuations, government policy will exhibit inefficiencies due to both a time-consistency problem and the political friction. This is where institutional constraints may play a role.

3.2 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 $\omega \in (0, 1]$ determines the degree of benevolence of the

government, where $\omega = 1$ means the government is fully benevolent. The exogenous state of the economy is given by the values of parameters $\{\gamma, \omega, \zeta, \theta_b, \delta\}$.

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, real return on private assets, 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 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 target adopted by the Federal Reserve since 2012. 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. Later on, I look at how the results change when we vary the degree of government benevolence.

Tables 1 and 2 present the benchmark parameterization and target statistics, respectively. As we can see, expenditure over GDP in the benevolent economy is 3 percentage points higher than in the calibrated economy.

Table 1: Benchmark Calibration

α	β	σ	η	ϕ	ω	θ_b	δ
8.453	0.945	4.009	0.341	3.606	0.365	0.375	0.028

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

Table 2: Non-stochastic steady state statistics

Variable	Statistic	Calibrated	Benevolent
Debt over GDP	$\frac{B(1+\mu)}{Y}$	0.325	0.317
Inflation rate	π	0.036	0.020
Nominal interest rate	i	0.058	0.048
Real return on assets	$\frac{p_c \delta}{p_a}$	0.021	0.037
Revenue over GDP	$\frac{p_c \tau n}{Y}$	0.180	0.154
Expenditure over GDP	$\frac{p_c g}{Y}$	0.180	0.150

Note: "benevolent" refers to an economy with $\omega = 1$.

4 Constrained Discretionary Policy

4.1 Accounting

In order to place constraints on government policy we first need to define some relevant macroeconomic variables.

Let us start with nominal GDP, defined as $Y_t = p_{x,t}\eta x_t + p_{c,t}(c_t + g_t)$, which using (2) and (3) implies

$$Y_t = \frac{(1+\theta_{b,t}B_t)[\eta\phi x_t + \gamma_t U_{c,t}(c_t+g_t)]}{\phi x_t}. \tag{13}$$

Note that nominal GDP, as all other nominal variables, is normalized by the aggregate money stock.

For any given day-good and night-good expenditure shares, ς_x and ς_c, respectively, the price level can be defined as: $P_t = \varsigma_x p_{x,t} + \varsigma_c p_{c,t}$. Using (2) and (3) we obtain

$$P_t = \frac{(1+\theta_{b,t}B_t)(\varsigma_x\phi + \varsigma_c\gamma_t U_{c,t})}{\phi x_t}. \tag{14}$$

Thus, we can define inflation as $1+\pi_t \equiv P_t(1+\mu_{t-1})/P_{t-1}$ and expected inflation as $1+\pi^e_{t+1} \equiv E_t[P_{t+1}(1+\mu_t)/P_t]$. Using (5) and (14) we get

$$1+\pi^e_{t+1} = \beta E_t\left[\frac{(1+\theta_{b,t+1}B_{t+1})(\varsigma_x\phi+\varsigma_c\gamma_{t+1}U_{c,t+1})}{\phi x_{t+1}(\varsigma_x\phi+\varsigma_c\gamma_t U_{c,t})}\right] E_t\left[\frac{x_{t+1}(\eta u_{x,t+1}+(1-\eta)\phi)}{(1+\theta_{b,t+1}B_{t+1})}\right]. \tag{15}$$

The nominal interest rate is defined as $i_t \equiv 1/q_t - 1$, using (7).

The primary deficit over GDP is defined as $d_t \equiv p_{c,t}(g_t - \tau_t\zeta_t n_t)/Y_t$. Using (3), (6) and (13) we obtain

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

The total fiscal deficit includes the primary deficit plus interest payments on the debt. Let $D_t \equiv d_t + \frac{(1+\mu_t)(1-q_t)B_{t+1}}{Y_t}$.

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

$$\frac{(1+\mu_t)B_{t+1}}{Y_t} = \frac{\beta B_{t+1}}{\eta\phi x_t + \gamma_t U_{c,t}(c_t+g_t)} E_t\left[\frac{x_{t+1}(\eta u_{x,t+1}+(1-\eta)\phi)}{(1+\theta_{b,t+1}B_{t+1})}\right] \tag{17}$$

4.2 Policy constraints

Constraints on government actions can be loosely categorized as constraints on monetary policy and constraints on fiscal policy. The first type being targets for nominal rates and the second type being limits on fiscal variables.

I will consider two constraints on monetary policy. An inflation target restricts a government to implement policy so that expected inflation is within a given interval, that is, $\pi^e_{t+1} \in [\underline{\pi}, \bar{\pi}]$. Similarly, an interest rate target restricts policy to be consistent with the nominal interest rate fluctuating within a given interval, that is, $i_t \in [\underline{i}, \bar{i}]$. For the purpose of the exercises in this paper, I will focus on strict targets: $\underline{\pi} = \bar{\pi}$ and $\underline{i} = \bar{i}$

Constraints on fiscal variables take the form of inequality constraints. I consider ceilings on the primary deficit, the total deficit and debt, all in terms of GDP, as well as limits on the nominal value of outstanding debt. That is, constraints of the form: $d_t \leq \bar{d}$, $D_t \leq \bar{D}$, $(1+\mu_t)B_{t+1}/Y_t \leq \bar{b}$ and $B_{t+1} \leq \bar{B}$. Note that even though B is the bond-money ratio, the last constraint should be interpreted as a limit on the nominal stock of debt, similar to the debt ceiling imposed by the US Congress.

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 during a severe crisis. 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.

4.3 Optimal constraints in non-stochastic economy

Table 3 presents the optimal values of each policy constraint for the case of a non-stochastic economy. The values are compared to the steady state statistics of the calibrated and benevolent economies. Recall that the steady state is constraint efficient, so all the welfare gains come from mitigating the political friction.

Table 3: Optimal constraints in non-stochastic economy

Constraint	Steady State	Benevolent	Optimal Value	Welfare Gain
Inflation	0.036	0.020	0.018	0.6%
Interest rate	0.058	0.048	0.047	0.6%
Primary deficit	0.000	−0.004	−0.008	0.7%
Deficit	0.018	0.011	0.008	0.5%
Debt	0.325	0.317	0.325	0.1%
Debt limit	0.325	0.317	0.234	0.2%

Note: The "debt limit" constraints the debt amount but is here expressed in terms of GDP.

The optimal values are evaluated at the steady state of the non-stochastic economy, in terms of equivalent compensation, measured in units of night-good consumption. The gains for all the types of policy constraints go from a maximum of 0.7% for the case of a primary deficit ceiling to a minimum of 0.2% for the case of a debt ceiling. Note that all types of constraints improve welfare and that the optimal values are very close to the policies implemented by a benevolent government.

4.4 Big government

Consider now the case of an economy with a less benevolent government. The first column of Table 4 shows the steady state statistics of an economy with $\omega = 0.250$. 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 4: Optimal constraints in non-stochastic economy with a big government

Constraint	Big Government	Benevolent	Optimal Value	Welfare Gain
Inflation	0.053	0.020	0.011	3.7%
Interest rate	0.068	0.048	0.043	3.7%
Primary deficit	0.004	−0.004	−0.017	5.3%
Deficit	0.025	0.011	−0.007	3.3%
Debt	0.333	0.317	0.310	0.3%
Debt limit	0.333	0.317	0.252	0.8%

Note: The "debt limit" constraints the debt amount but is here expressed in terms of GDP.

When compared to the benchmark results in Table 3, the optimal constraints are typically more strict when facing a less benevolent government (the debt ceiling being the only exception). Hence, the optimal value for policy constraints deviate further from the benevolent case.

Welfare gains for all types of constraint increase by an order of magnitude. Notably, the best prescription remains to run a primary surplus, in this case 1.7% of GDP. Running a primary surplus is now significantly better than an inflation or interest target and a deficit ceiling. In turn, these constraints are significantly better than a debt-to-GDP ceiling or a nominal debt limit. All these results continue to hold if we lower the benevolence of the government even further.

4.5 Calibration and numerical approximation of stochastic economies

I will consider economies with only one type of shock at a time. That is, there is an economy where only productivity fluctuates, another where only government benevolence fluctuates, etc. 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 and s_3 ("good") is included for symmetry. 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, low real interest rate and low asset returns.

The transition matrix is characterized by two values ϖ and ϖ^* such that $\varpi_{1,1} = \varpi_{33} = \varpi$, $\varpi_{1,2} = \varpi_{3,1} = 1-\varpi$, $\varpi_{13} = \varpi_{3,1} = 0$, $\varpi_{22} = \varpi^*$ and $\varpi_{2,1} = \varpi_{2,3} = (1-\varpi^*)/2$. In other words, ϖ^* is the probability of remaining in the normal state of the world, with an equal chance of transitioning to a crisis (s_3) or boom (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. 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 on Table 5.

Table 5: Stochastic economy parameterization

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

$\varrho_\gamma = 0.43$	$\varrho_\omega = 0.41$	$\varrho_\zeta = 0.15$	$\varrho_\theta = -0.20$	$\varrho_\delta = 0.50$

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 $i = \{1, \ldots, N_S\}$, and set an initial guess.

(ii) Construct the following system of equations: for every point in the debt and exogenous state grids, evaluate equations (8)—(12). Since (9) 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.

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.

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

Once the equilibrium for a stochastic economy is computed, the economy is simulated to provide a visual representation of the (possibly constrained) policy response to an adverse shock. In the initial period $t = -10$ debt is equal to steady state debt in the non-stochastic economy, B^* and the economy is in the normal state, s_2. In period $t = 1$, an adverse shock hits, i.e., $s = s_1$, and the economy stays in this state for 10 periods. In period $t = 11$, the economy returns to the normal state, $s = s_2$, and stays there from then on.

4.6 Benchmark: Demand shocks

As a benchmark case, here I analyze an economy subjected to fluctuations in aggregate demand, i.e., with shocks to γ. In following sections, I verify that the results obtained for demand shocks also apply to other types of shocks.

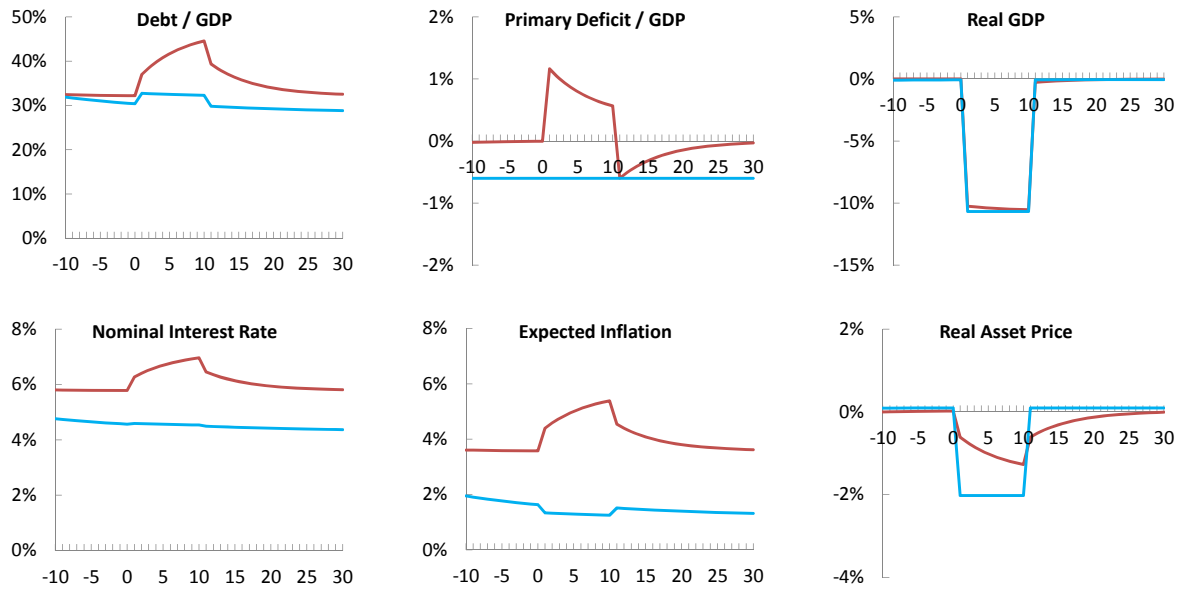
Table 6 summarizes the welfare effects of imposing constraints on policy in an economy facing demand shocks. The three right-most columns show the welfare effects of imposing policy constraints always, in normal and good times and in normal times only, respectively. The best case is shown in bold. For 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).

Table 6: Demand shocks—Welfare gains over full discretion

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times
Inflation	0.036	0.0%	0.0%	**0.0**%
Interest rate	0.057	0.2%	0.2%	**0.2**%
P. Deficit	−0.006	**0.7**%	0.6%	0.6%
Deficit	0.008	**0.5**%	0.4%	0.4%
Debt	0.325	0.1%	**0.1**%	0.1%
Debt limit	0.234	**0.2**%	0.2%	0.2%

There are several important observations. First, a primary deficit ceiling improves welfare

Figure 1: Demand shock: full discretion vs optimal primary deficit ceiling



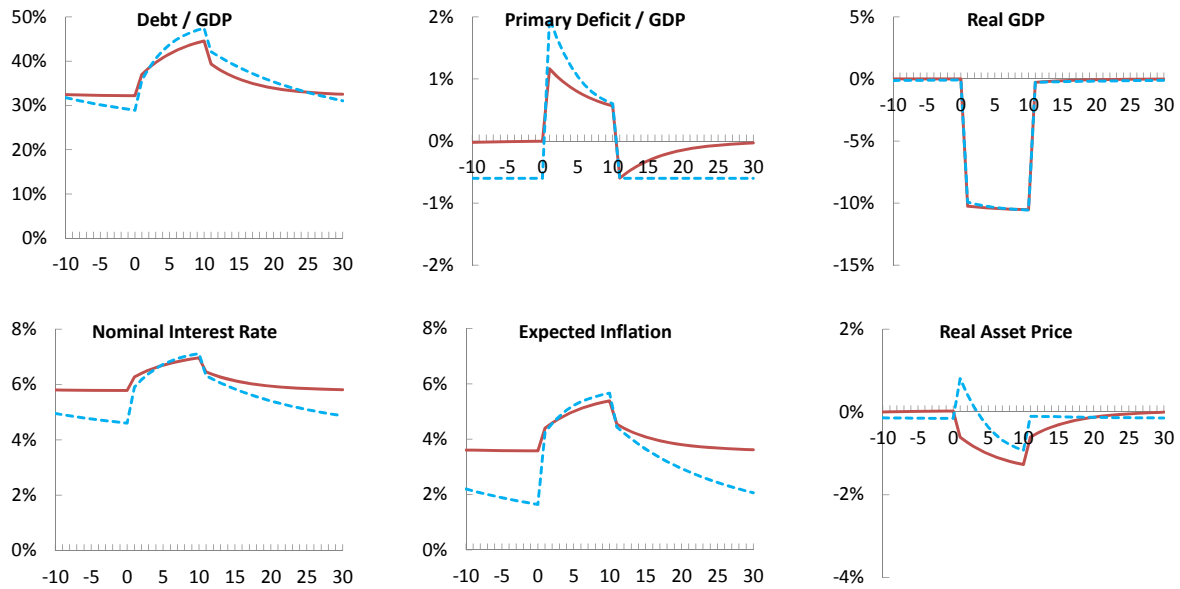
Note: full discretion (red solid line) and primary deficit ceiling (light blue line).

the most. The optimal value is to have a small primary surplus of about half a percent of output. Note that this is the same result we obtained in the non-stochastic case. Second, for all types of constraints, most of the welfare gains come from imposing constraints in normal times. Third, suspending constraints during abnormal (both bad and good) times carries a small welfare cost in the case of primary and total deficit ceilings and debt limit.

Figure 1 compares the policy response to a negative demand shock under full discretion vs the optimal primary deficit ceiling, as indicated by the results in Table 6. The constrained policy displays a significantly more muted response to the adverse shock. The better welfare performance of the optimal primary deficit constraint comes from the lower inflation distortion it allows. In effect, by implementing a primary surplus, inflation can be lower, both in normal and adverse times.

Figure 2 considers the case when we allow for the primary deficit ceiling to be suspended in abnormal times. As shown in Table 6, most of the welfare gains from a primary deficit ceiling came from imposing it during normal times. The constrained policy response looks now qualitatively more similar to the fully discretionary policy. There are two important differences. First, during normal times, the requirement of a primary surplus induces a lower inflation than under discretion, which mitigated the social losses due to political frictions. Second, when the economy returns to normal, both debt and inflation transition gradually back to their (long-run) normal levels. I.e., even though the government is constrained to run a surplus, it is still able to adequately smooth distortions over time, which is always desirable. This is why an inflation target imposed during normal times only (of say 2% annual) does not work as effectively; although inflation is typically lower, once the economy returns back to normal, inflation needs to adjust immediately, which is costly since it does not allow for sufficient distortion-smoothing.

Figure 2: Demand shock: full discretion vs optimal primary deficit ceiling in only normal times

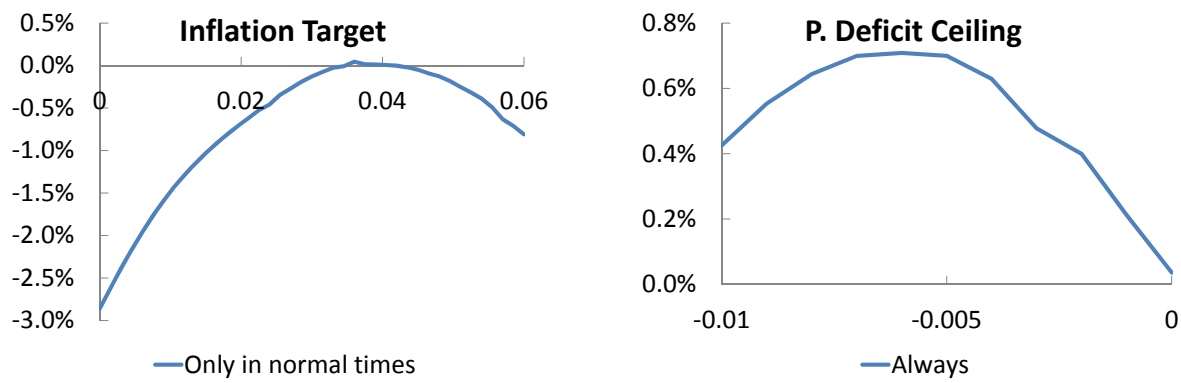


Note: full discretion (red solid line) and primary deficit ceiling in normal times only (light blue dashed line).

4.7 Wrong targets and improper timing

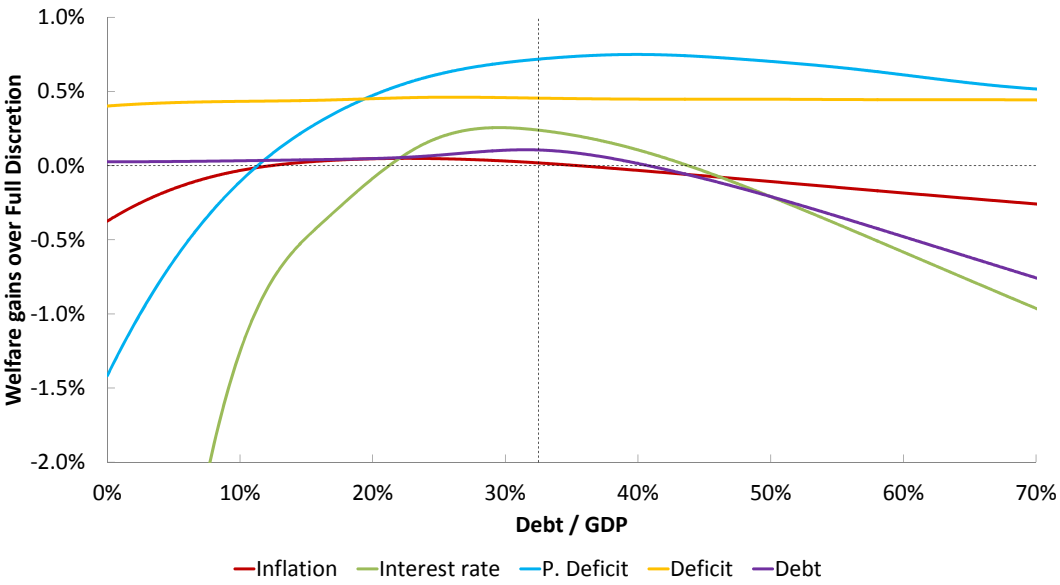
A pertinent question arises: is it costly to set the wrong value for a constraint? Figure 3 shows two illustrative cases. As we can see on the left panel, an inflation target that is implemented only in normal times is at best as good as full discretion. However, picking a target that is too low or two high can lead to large welfare losses. For example, setting the inflation target at its optimal non-stochastic value of 1.8% annual (see Table 3) implies a welfare loss of about 1% of consumption. Losses are even larger as we further lower the target. In contrast, a primary deficit ceiling provides benefits for a larger range: small primary surpluses 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 incorrect implementation.

Figure 3: Demand shock: Welfare gains as a function of constraints



Another potential concern is the fact that constraints could be implemented at inappropriate times. For example, the calculations for optimal constraints rely on them being implemented around the stochastic steady state in normal times, which is very close to the non-stochastic 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 4 provides an answer to this question for selected constraints. The optimal inflation target can lead to some welfare losses when implemented far from the steady 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. The optimal debt-to-GDP ceiling 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.

Figure 4: Demand shock: Welfare gains of optimal constraints as a function of initial debt level



Monetary targets (inflation and interest rates) have a minor upside and are instead potentially very costly when implemented far away from the non-stochastic steady state. Coupled with the findings in Figure 3, this suggests that monetary targets are generally not a good idea in economies with potentially large aggregate demand shocks. In contrast, as shown in Tables 3 and 3, they improve welfare significantly in non-stochastic economies (and by extension, probably also in economies subjected to milder aggregate fluctuations).

4.8 Other shocks

In this section, I verify that the main results derived for aggregate demand shocks also apply to other types of shocks.

4.8.1 Expenditure shocks

Table 7 summarizes the welfare effects of imposing constraints on policy in an economy facing non-valued expenditure shocks.

Table 7: Expenditure shocks—Welfare gains over full discretion

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times
Inflation	0.040	0.0%	0.1%	**0.1**%
Interest rate	0.059	**0.7**%	0.5%	0.5%
P. Deficit	−0.007	**1.3**%	0.5%	0.5%
Deficit	0.004	**0.9**%	0.3%	0.3%
Debt	0.280	**0.5**%	0.3%	0.3%

Again, a primary deficit ceiling improves welfare the most and the lessons derived from the economy with a demand shock apply for this case as well. Since the rise in expenditure stems from the government becoming less benevolent, the gains from imposing fiscal constraints in bad times are large, about the same as those stemming from imposing them in normal times.

An important difference with the economy subjected to demand shocks is that with expenditure shocks an interest rate target improves welfare significantly. In contrast, an inflation target offers very minor potential gains.

4.8.2 Productivity shocks

Table 8 summarizes the welfare effects of imposing constraints on policy in an economy facing productivity shocks.

Table 8: Productivity shocks—Welfare gains over full discretion

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times
Inflation	0.037	−0.2%	−0.1%	**0.0**%
Interest rate	0.057	0.1%	0.2%	**0.3**%
P. Deficit	−0.006	**0.7**%	0.7%	0.6%
Deficit	0.006	0.5%	**0.5**%	0.4%
Debt	0.238	0.2%	**0.2**%	0.2%

For an economy facing productivity shocks, the lessons for policy constraints are the same as for the economies described above. The best constraint is to always impose a minimum surplus of about 0.5% of output.

4.8.3 Financial shocks

Similar lessons can de drawn when considering financial shocks, more specifically fluctuations in liquidity (θ) and asset-return (δ). Tables 9 and 10 summarize the welfare effects of imposing constraints on policy in these cases. Again, a primary surplus of about half a percentage point of

GDP, imposed at all times, is the best constraint. Also, most welfare gains arise from imposing the constraint during normal times.

Table 9: Liquidity shocks—Welfare gains over full discretion

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times
Inflation	0.038	**0.0**%	0.0%	0.0%
Interest rate	0.059	−0.1%	0.2%	**0.4**%
P. Deficit	−0.006	**0.7**%	0.6%	0.6%
Deficit	0.006	**0.5**%	0.4%	0.4%
Debt	0.280	**0.2**%	0.2%	0.2%

Table 10: Asset-Return shocks—Welfare gains over full discretion

Constraint	Optimal Value	Always	Suspended in bad times	Only in normal times
Inflation	0.049	0.0%	0.0%	**0.3**%
Interest rate	0.057	0.0%	0.3%	**0.3**%
P. Deficit	−0.006	**0.7**%	0.7%	0.6%
Deficit	0.006	**0.5**%	0.5%	0.4%
Debt	0.234	**0.2**%	0.2%	0.2%

5 General Lessons and Conclusions

There are several general lessons that can be drawn from the exercises presented in this paper.

(i) A small primary surplus is always the best policy. For an economy calibrated to the U.S. the optimal primary surplus is about half percent of output.

(ii) Inflation targets have small (and sometimes detrimental) welfare effects relative to full discretion.

(iii) Most welfare gains come from imposing constraints in normal times.

(iv) Should we ever suspend constraints? The answer is definitely no in the case of (non-socially-valued) expenditure shocks. For other types of shocks, the welfare loss from suspending constraints during bad or abnormal times is minimal.

(v) Mistakes can be costly. Either choosing the wrong policy target (e.g., a low inflation target) or imposing a constraint at inappropriate times (e.g., a primary surplus when debt is low or a debt ceiling when debt is large) can lead to large welfare losses.

(vi) Less benevolent economies (in this paper, ones with inefficiently larger governments) benefit most from imposing constraints on policy.

References

Aiyagari, S. R., Marcet, A., Sargent, T. J. and Seppälä, J. (2002), 'Optimal taxation without state-contingent debt', *The Journal of Political Economy* **110**(6), 1220–1254.

Albanesi, S., Chari, V. V. and Christiano, L. J. (2003), 'Expectation traps and monetary policy', *The Review of Economic Studies* **70**(4), 715–741.

Azzimonti, M., Battaglini, M. and Coate, S. (2010), Analyzing the case for a balanced budget amendment to the U.S. constitution. Mimeo.

Barro, R. J. (1979), 'On the determination of the public debt', *The Journal of Political Economy* **87**(5), 940–971.

Barro, R. J. and Gordon, D. B. (1983), 'A positive theory of monetary policy in a natural-rate model', *The Journal of Political Economy* **91**, 589–610.

Barseghyan, L. and Battaglini, M. (2012), Growth and fiscal policy: a positive theory. Mimeo.

Bassetto, M. and Sargent, T. J. (2006), 'Politics and efficiency of separating capital and ordinary government budgets', *The Quarterly Journal of Economics* **121**(4), 1167–1210.

Benhabib, J. and Rustichini, A. (1997), 'Optimal taxes without commitment', *Journal of Economic Theory* **77**(2), 231–259.

Bohn, H. and Inman, R. P. (1996), 'Balanced-budget rules and public deficits: evidence from the U.S. states', *Carnegie-Rochester Conference Series on Public Poliy* **45**, 13–76.

Brennan, G. and Buchanan, J. M. (1977), 'Towards a tax constitution for leviathan', *Journal of Public Economics* **8**, 255–273.

Chari, V. and Kehoe, P. J. (2007), 'On the need for fiscal constraints in a monetary union', *Journal of Monetary Economics* **54**, 23992408.

Halac, M. and Yared, P. (2012), Fiscal rules and discretion under persistent shocks. Mimeo.

Harchondo, J. C., Martinez, L. and Roch, F. (2012), Fiscal rules and the sovereign default premium. Working Paper 12-01, The Federal Reserve Bank of Richmond.

Kiyotaki, N. and Moore, J. (2002), 'Evil is the root of all money', *American Economic Review* **92**(2), 62–66.

Kydland, F. E. and Prescott, E. C. (1977), 'Rules rather than discretion: The inconsistency of optimal plans', *The Journal of Political Economy* **85**(3), 473–491.

Lagos, R. and Wright, R. (2005), 'A unified framework for monetary theory and policy analysis', *The Journal of Political Economy* **113**(3), 463–484.

Lucas, R. E. and Stokey, N. L. (1983), 'Optimal fiscal and monetary policy in an economy without capital', *Journal of Monetary Economics* **12**(1), 55–93.

Martin, F. M. (2009), 'A positive theory of government debt', *Review of Economic Dynamics* **12**(4), 608–631.

Martin, F. M. (2010), 'Markov-perfect capital and labor taxes', *Journal of Economic Dynamics and Control* **34**(3), 503–521.

Martin, F. M. (2011), 'On the joint determination of fiscal and monetary policy', *Journal of Monetary Economics* **58**(2), 132–145.

Martin, F. M. (2012), 'Government policy response to war-expenditure shocks', *The B.E. Journal of Macroeconomics* **12**(1), (Contributions), Article 25.

Martin, F. M. (2013), 'Government policy in monetary economies', *International Economic Review* **54**(1), 185–217.

Martin, F. M. (2015), 'Debt, inflation and central bank independence', *European Economic Review, forthcoming* .

Martin, F. M. and Waller, C. J. (2012), 'Sovereign debt: a modern Greek tragedy', *Review, Federal Reserve Bank of St. Louis* (Issue Sep), 321–340.

Mishkin, F. S. (1999), 'International experiences with different monetary policy regimes', *Journal of Monetary Economics* **43**(3), 579–605.

Strotz, R. H. (1956), 'Myopia and inconsistency in dynamic utility maximization', *The Review of Economic Studies* **23**(3), 165–180.

Svensson, L. E. O. (1999), 'Infation targeting as a monetary policy rule', *Journal of Monetary Economics* **43**(3), 607–654.