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WP 12-01

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Fiscal rules and the sovereign default premium *

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Abstract

We find the optimal target values for fiscal rules and measure their aggregate effects using a model of sovereign default. We calibrate the model to an economy that pays a significant sovereign default premium when the government is not constrained by fiscal rules. For different levels of the default premium, we find that a government with a debt of 38 percent of trend income (typical in the case studied here) chooses to commit to a debt ceiling of 30 percent of trend income that starts being enforced four years after its announcement. This rule generates expectations of lower future indebtedness, and thus it allows the government to borrow at interest rates significantly lower than the ones it pays without a rule. We also study the case in which the government conducts a voluntary debt restructuring to capture the capital gains from the increase in its debt market value implied by the existence of a fiscal rule. In this case, the government is found to choose instead a debt ceiling of 25 percent of trend income that starts being enforced less than two years after its announcement. After the imposition of the debt ceiling, lower debt levels allow the government to implement a less procyclical fiscal policy that reduces consumption volatility. However, the government prefers a procyclical debt ceiling that implies a larger reduction of the default probability at the expense of a higher consumption volatility.

JEL classification: F34, F41.

Keywords: Fiscal Rules, Debt Ceiling, Fiscal Consolidation, Sovereign Default, Debt Restructuring, Countercyclical Fiscal Policy, Endogenous Borrowing Constraints, Long-term Debt.

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1 Introduction

This paper examines the optimality of fiscal rules and measures their aggregate effects using a baseline sovereign default framework. Fiscal rules are restrictions imposed (often in a country's laws or its constitution) on future governments' ability to conduct fiscal policy. We abstract from fiscal rules enforcement issues and focus on the effects that a fiscal rule will have if the government can commit to enforce it.[1] Thus, our analysis is likely to offer an upper bound on the benefits that can be derived from fiscal rules.

A consensus has emerged among policymakers regarding the desirability of fiscal rules targeting low sovereign debt levels, which help deter fiscal crises and facilitate implementation of more countercyclical fiscal policies.[2] Nevertheless, significant uncertainty remains about the optimal value of fiscal rules' targets. For instance, Blanchard (2011) asks: "What levels of public debt should countries aim for? Are old rules of thumb, such as trying to keep the debt to GDP ratio below 60 percent in advanced countries, still reliable?"

The first contribution of this paper is to shed light on the optimal target value for fiscal rules and to quantify the effects of rules that employ an optimal target value . To that end, we study a sovereign default framework à la Eaton and Gersovitz (1981), which is commonly used for quantitative studies of sovereign debt.[3]

First, we calibrate this model to an economy that pays a significant sovereign default premium without a rule (Argentina before the 2001 default). The calibrated model generates plausible values for debt levels and the mean and standard deviation of the interest rate spread paid by

[1]Some countries have mitigated enforcement limitations on fiscal rules, for instance, by granting them constitutional status. Germany (in 2009) and Spain (in 2011), for example, amended their constitutions to introduce fiscal rules. The supermajorities, referendums, or waiting periods typically required to amend a constitution limit the discretionary power of policymakers subsequently in office (see IMF (2009)).

[2]For instance, in an International Monetary Fund Staff Position Note, Blanchard et al. (2010) argue that "a key lesson from the crisis is the desirability of fiscal space to run larger fiscal deficits when needed." They also note that "medium-term fiscal frameworks, credible commitments to reducing debt-to-GDP ratios, and fiscal rules (with escape clauses for recessions) can all help in this regard." Discussions about the overhaul of the fiscal rules in the Eurozone provide other examples of this view.

[3]See, for instance, Aguiar and Gopinath (2006), Arellano (2008), Benjamin and Wright (2008), Boz (2011), Lizarazo (2005, 2006), and Yue (2010). The models in these studies share blueprints with the models used in studies of household bankruptcy (see, for example, Athreya et al. (2007), Chatterjee et al. (2007), Li and Sarte (2006), Livshits et al. (2008), and Sanchez (2010)). There are also sovereign default studies that assume non-strategic defaults (see, for example, Bi (2011) and Bi and Leeper (2012)).

the sovereign–that is, the difference between the sovereign bond yield and the risk-free interest rate.

The optimal target values for fiscal rules in the benchmark no-rule economy are then determined. We assume that a fiscal rule consists of (i) a debt ceiling and (ii) the number of periods between the period in which the rule is announced (the "announcement period") and the period in which the ceiling starts being enforced. This assumption is made for two reasons. First of all, according to the International Monetary Fund's (IMF's) fiscal rules database, 62 of the 82 countries with fiscal rules in 2009 had debt-to-GDP ceilings in their rules. Second, transition periods are commonly granted when fiscal rules are established. For instance, Germany amended its constitution in 2009 to introduce a fiscal rule that is scheduled to be enforced after 2016 for the federal government and after 2020 for regional governments. Similarly, Spain amended its constitution in 2011 to introduce a fiscal rule to be enforced after 2020.

We first study rules with constant debt ceilings (that are not a function of aggregate income). We find the optimal debt ceiling rule for different announcement period conditions. We consider pre-rule conditions characterized by a debt level of 38 percent of trend income (similar to the debt level on which Argentina defaulted) and different income levels. We find that the income level does not substantially affect the rule to which the government would like to commit: a debt ceiling of 30 percent of trend income with a delay of four years between the announcement period and the period in which the ceiling starts being enforced. Such a policy implies an increase in welfare that is equivalent to a permanent increase in consumption of about 0.23 percent. The government benefits from committing to such a rule because such a commitment mitigates a debt dilution problem that exists in the presence of default risk (see Hatchondo et al. (2010b) and the references therein).[4] A fiscal rule allows the government to commit as well to lower future debt levels and thus to default less frequently. This explains how imposing a debt ceiling creates new borrowing opportunities for the government: For the same current-period debt level, the government pays a lower interest rate because of the expectation that future default probabilities

[4]Our framework allows for debt dilution because we assume long-term debt, which Chatterjee and Eyigungor (2012) and Hatchondo and Martinez (2009) show is essential for accounting for interest rate dynamics in a framework with sovereign defaults.

are lower.

The paper's second contribution is to study the trade-off between bondholders' capital gains and the transition cost implied by a stronger fiscal adjustment. With a rule imposing a lower debt ceiling or a ceiling that is enforced sooner, creditors enjoy a larger capital gain derived from the increase in the market value of their bond holdings. We study the case in which the government conducts a voluntary debt restructuring that enables it to capture these capital gains. In this case, we find that the government chooses a ceiling of 25 percent of trend income that starts being enforced less than two years after the rule announcement. Bondholders are willing to forgive a fraction of the government's debt in exchange for the implementation of the rule. This fraction is determined to be increasing with respect to the pre-rule interest rate spread. For instance, with a pre-rule spread of 5 (15) percent, bondholders are found to be willing to forgive up to 21 (44) percent of the government's debt. Welfare gains from implementing both the restructuring and the rule are also determined to be increasing with respect to the pre-rule spread and amount to a permanent consumption increase ranging from 1.0 to 2.3 percent.

The paper's third contribution is to measure the effects of fiscal rules on the procyclicality of fiscal policy and, through that, on the volatility of private consumption. In our benchmark economy without rules, borrowing becomes more expensive when income is low. Because of this, the government reduces its borrowing when income is low, and thus, it conducts a procyclical fiscal policy (see Cuadra et al. (2010)).[5] We show that the imposition of a constant debt ceiling mitigates borrowing terms' responsiveness to income shocks, which enables the government to conduct a less procyclical fiscal policy that reduces consumption volatility. However, the government is found to prefer a procyclical debt ceiling that implies a greater reduction of the default probability at the expense of a higher consumption volatility.[6]

[5]This is consistent with evidence for emerging economies, as documented by Gavin and Perotti (1997), Ilzetzki and Vegh (2008), Kaminsky et al. (2004), Talvi and Vegh (2009), and Vegh and Vuletin (2011).

[6]It should be mentioned that our analysis of the cyclicality of fiscal policy may be limited, because in the model employed, fiscal policy does not play a role in stabilizing aggregate income.

1.1 Related Literature

In spite of the great interest in fiscal rules among policymakers, theoretical studies on fiscal rules are relatively scarce. A number of theoretical studies focus on the desirability of a balanced-budget rule for the U.S. federal government (see Azzimonti et al. (2010) and the references therein). Garcia et al. (2011) compare a balanced-budget rule with a structural-surplus rule. Medina and Soto (2007) use a model of the Chilean economy to show that a structurally balanced fiscal rule mitigates the macroeconomic effects of copper price shocks. Beetsma and Uhlig (1999) show how, by imposing lower debt levels, the Stability and Growth Pact may help control inflation in the European Monetary Union. Beetsma and Debrun (2007) discuss how additional flexibility in the Stability and Growth Pact may improve welfare. Pappa and Vassilatos (2007) and Poplawski Ribeiro et al. (2008) find that debt ceilings may be preferable to constraints on the government's deficit.

The studies mentioned in the previous paragraph abstract from the effect that expectations about future indebtedness may have on the default premium (the main focus of our analysis). In these studies, rules may be beneficial because of a conflict of interest between the government and private agents (for instance, because the government is myopic or because of political polarization) or among governments of different countries in a monetary union. In contrast, the current study examines a model with benevolent governments in which there is a conflict between current and future governments: there is a debt dilution problem caused by the fact that future governments borrow more than what the current government would like them to borrow.

Our study complements Bi and Leeper (2012). They study an environment with non-strategic defaults, one-period debt, and exogenous decision rules for government expenditures and taxes. They measure how fiscal reforms, modeled as changes to the government's decision rules, impact in the relationship between public debt ratios and default risk. We study a model with endogenous fiscal policy in which the government issues long-term debt. The latter introduces a quantitatively significant motive for restricting future governments' policies.

A number of empirical studies analyze the relationship between fiscal rules and fiscal policy (for instance, Poterba (1996) reviews the literature for U.S. states, and Debrun et al. (2008)

present evidence for Europe) and between fiscal rules and the government's financing costs (see, for example, Eichengreen and Bayoumi (1994), Heinemann et al. (2011), Iara and Wolff (2011), Lowry and Alt (2001), and Poterba and Rueben (1999)). However, difficulties in identifying the effects of fiscal rules are well documented (see, for instance, Poterba (1996) and Heinemann et al. (2011)). We measure these effects through the lens of a default model. When comparing predictions in this paper with past experiences with fiscal rules, one should keep in mind that here it is assumed that the government can commit to enforcing a rule, whereas this is not necessarily the case in reality.

The exercises presented in this paper also illustrate how a sovereign default framework à la Eaton and Gersovitz (1981) can be used to evaluate fiscal consolidation programs and the implied sovereign debt dynamics. An alternative approach is to use the debt sustainability framework (see Ghosh et al. (2011) and the references therein) commonly used for policy analysis (see, for instance, IMF Article IV country reports). In contrast with the debt sustainability framework, the sovereign default framework features endogenous borrowing and default policies, as well as an endogenous sovereign spread function that is calibrated to match features of the data. This allows the sovereign default framework to better capture the effects of imposing fiscal rules.

The rest of the article proceeds as follows. Section 2 introduces the model. Section 3 discusses the calibration. Section 4 presents the results. Section 5 concludes.

2 The model

There is a single tradable good. The economy receives a stochastic endowment stream of this good y_t, where

$$\log(y_t) = (1-\rho)\,\mu + \rho \log(y_{t-1}) + \varepsilon_t,$$

with $|\rho| < 1$, and $\varepsilon_t \sim N\left(0, \sigma_\epsilon^2\right)$.

The government's objective is to maximize the present expected discounted value of future utility flows of the representative agent in the economy, namely

$$E\left[\sum_{t=0}^{\infty}\beta^{t}u\left(c_{t}\right)\right],$$

where E denotes the expectation operator, β denotes the subjective discount factor, and the utility function is assumed to display a constant coefficient of relative risk aversion denoted by γ. That is,

$$u\left(c\right)=\frac{c^{1-\gamma}-1}{1-\gamma}.$$

As in Hatchondo and Martinez (2009) and Arellano and Ramanarayanan (2010), we assume that a bond issued in period t promises an infinite stream of coupons that decrease at a constant rate δ. In particular, a bond issued in period t promises to pay one unit of the good in period $t+1$ and $(1-\delta)^{s-1}$ units in period $t+s$, with $s\geq 2$.

Each period, the government makes two decisions. First, it decides whether to default. Second, it chooses the number of bonds that it purchases or issues in the current period.

As previous studies of sovereign default, we assume that the recovery rate for debt in default—i.e., the fraction of the loan lenders recover after a default—is zero and that the cost of defaulting is not a function of the size of the default. The second assumption implies that, as in Arellano and Ramanarayanan (2010), Chatterjee and Eyigungor (2012) and Hatchondo and Martinez (2009), when the government defaults, it does so on all current and future debt obligations. This is consistent with the behavior of defaulting governments in reality. Sovereign debt contracts often contain an acceleration clause and a cross-default clause. The first clause allows creditors to call the debt they hold in case the government defaults on a payment. The cross-default clause states that a default on any government obligation also constitutes a default on the contracts containing that clause. These clauses imply that after a default event, future debt obligations become current.

There are two costs of defaulting in the model. First, a defaulting sovereign is excluded from capital markets. Once excluded, the country regains access to capital markets with probability $\psi\in[0,1]$.[7] Second, if a country has defaulted on its debt, it faces an income loss of $\phi\left(y\right)$ in

[7]Hatchondo et al. (2007) solve a baseline model of sovereign default with and without the exclusion cost and show that eliminating this cost affects significantly only the debt level generated by the model.

every period in which it is excluded from capital markets. Following Chatterjee and Eyigungor (2012), we assume a quadratic loss function $\phi(y) = d_0 y + d_1 y^2$.

Following Arellano and Ramanarayanan (2010), we assume that the price of sovereign bonds satisfies a no arbitrage condition with stochastic discount factor $M(y', y) = exp(-r - \alpha\varepsilon' - 0.5\alpha^2\sigma_\epsilon^2)$, where r denotes the risk-free rate at which lenders can borrow or lend. This allows us to introduce a risk premium. Several studies document that the risk premium is an important component of sovereign spreads and that a significant fraction of the spread volatility in the data is accounted for by the volatility in the risk premium (see, for example, Borri and Verdelhan (2009), Broner et al. (2012), Longstaff et al. (2011), and González-Rozada and Levy Yeyati (2008)).

The model of the discount factor we use is a special case of the discrete-time version of the Vasicek one-factor model of the term structure (see Vasicek (1977) and Backus et al. (1998)). With this formulation, the risk premium is determined by the income shock in the borrowing economy. It may be more natural to assume that the lenders' valuation of future payments is not perfectly correlated with the sovereign's income. However, the advantage of our formulation is that it avoids introducing additional state variables to the model. In this paper, benefits from introducing fiscal rules result from the mitigation of the debt dilution problem. Hatchondo et al. (2010b) show that the effects of debt dilution on default risk are robust to assuming that there is a shock to the cost of borrowing that is not perfectly correlated with the sovereign's income, and to assuming that lenders are risk neutral.

We focus on Markov Perfect Equilibrium. That is, we assume that in each period, the government's equilibrium default and borrowing strategies depend only on payoff-relevant state variables. As discussed by Krusell and Smith (2003), there may be multiple Markov perfect equilibria in infinite-horizon economies. In order to avoid this problem, we solve for the equilibrium of the finite-horizon version of our economy, and we increase the number of periods of the finite-horizon economy until value functions and bond prices for the first and second periods of this economy are sufficiently close. We then use the first-period equilibrium functions as an approximation of the infinite-horizon-economy equilibrium functions.

2.1 Recursive formulation of the no-rule benchmark

We first present the recursive formulation for the benchmark economy, in which there is no fiscal rule. Let b denote the number of outstanding coupon claims at the beginning of the current period, and b' denote the number of outstanding coupon claims at the beginning of the next period. A negative value of b implies that the government was a net issuer of bonds in the past. Let d denote the current-period default decision. We assume that d is equal to 1 if the government defaulted in the current period and is equal to 0 if it did not. Let V denote the government's value function at the beginning of a period, that is, before the default decision is made. Let V_0 denote the value function of a sovereign not in default. Let V_1 denote the value function of a sovereign in default. Let F denote the conditional cumulative distribution function of the next-period endowment y'. For any bond price function q, the function V satisfies the following functional equation:

$$V(b,y) = \max_{d \epsilon \{0,1\}} \{dV_1(y) + (1-d)V_0(b,y)\}, \tag{1}$$

where

$$V_1(y) = u(y - \phi(y)) + \beta \int [\psi V(0,y') + (1-\psi) V_1(y')] F(dy' \mid y), \tag{2}$$

and

$$V_0(b,y) = \max_{b' \le 0} \left\{ u(y + b - q(b',y)[b' - (1-\delta)b]) + \beta \int V(b',y') F(dy' \mid y) \right\}. \tag{3}$$

The bond price is given by the following functional equation:

$$\begin{aligned} q(b',y) &= \int M(y',y)[1 - h(b',y')] F(dy' \mid y) \\ &\quad + (1-\delta) \int M(y',y)[1 - h(b',y')]\; q(g(b',y'),y') F(dy' \mid y), \end{aligned} \tag{4}$$

where h and g denote the future default and borrowing rules that lenders expect the government to follow. The default rule h is equal to 1 if the government defaults, and is equal to 0 otherwise. The function g determines the number of coupons that will mature next period. The first term in the right-hand side of equation (4) equals the expected value of the next-period coupon payment promised in a bond. The second term in the right-hand side of equation (4) equals the expected value of all other future coupon payments, which is summarized by the expected price at which the bond could be sold next period.[8]

Equations (1)-(4) illustrate that the government finds its optimal current default and borrowing decisions taking as given its future default and borrowing decision rules h and g. In equilibrium, the optimal default and borrowing rules that solve problems (1) and (3) must be equal to h and g for all possible values of the state variables.

Definition 1 *A Markov Perfect Equilibrium is characterized by*

1. a set of value functions V, V_1, and V_0
2. a default rule h and a borrowing rule g,
3. a bond price function q,

such that:

(a) given h and g, V, V_1, and V_0 satisfy functional equations (1), (2), and (3), when the government can trade bonds at q;

(b) given h and g, the bond price function q is given by equation (4); and

(c) the default rule h and borrowing rule g solve the dynamic programming problem defined by equations (1) and (3) when the government can trade bonds at q.

2.2 Fiscal rules

We study a set of fiscal rules $(\underline{b}(y), n)$ defined by a limit on the debt level

$$\underline{b}(y) = a_0 + a_1 y, \tag{5}$$

[8] Assuming risk-neutral lenders, Chatterjee and Eyigungor (2012) demonstrate that an equilibrium bond price function exist and is decreasing with respect to the debt level.

and by the number of transition periods between the announcement of the rule and the period in which the ceiling starts being enforced. The length of the transition is denoted by n. When the rule is announced, the government's maximization problem becomes non-stationary until the first enforcement period. After that period, the government solves the optimization problem described in equation (3) with the additional constraint $b' \geq \underline{b}(y)$.

2.3 Fiscal policy

Fiscal policy is very stylized in the sovereign default framework proposed by Eaton and Gersovitz (1981). The government may tax private agents in order to service its debt or may extend transfers to private agents using borrowing revenues. Each period, the government chooses the (possibly negative) level of tax revenues τ. When the country is in default, $\tau = 0$ and private agents consume all available resources ($c = y - \phi(y)$). When the country is not in default, private agents pay taxes ($c = y - \tau$) and the government uses tax revenues to service debt that is not rolled over, i.e., $\tau = -b + q\,(b', y)\,[b' - (1-\delta)b]$.

3 Calibration

As Hatchondo et al. (2010a), we solve the model numerically using value function iteration and interpolation.[9] As in most previous quantitative studies on sovereign default, we use Argentina before the 2001 default as a case study. Recall that we assume that the government can commit to its preferred rule. Therefore, it is likely that the policies we study were not available to Argentina before the 2001 default. This paper should not be interpreted as discussing policy options for Argentina but as a quantification of the role that credible fiscal rules could play in countries that pay a non-negligible default premium. The choice of Argentina as a case study facilitates the comparison of our paper with existing studies of sovereign default.

Table 1 presents the calibration. We assume that the representative agent in the sovereign economy has a coefficient of relative risk aversion of 2, which is within the range of accepted

[9] We use linear interpolation for endowment levels and spline interpolation for asset positions. The algorithm finds two value functions, V_1 and V_0. Convergence in the equilibrium price function q is also assured.

Sovereign's risk aversion	γ	2
Interest rate	r	0.01
Income autocorrelation coefficient	ρ	0.9
Standard deviation of innovations	σ_ϵ	0.027
Mean log income	μ	$(-1/2)\sigma_\epsilon^2$
Exclusion	ψ	0.282
Duration	δ	0.0341
Discount factor	β	0.961
Default cost	d_0	-0.69
Default cost	d_1	1.017
Risk premium	α	3

Table 1: Parameter values.

values in studies of business cycles. A period in the model refers to a quarter. The risk-free interest rate is set equal to 1 percent. As in Hatchondo et al. (2009), parameter values that govern the endowment process are chosen so as to mimic the behavior of GDP in Argentina from the fourth quarter of 1993 to the third quarter of 2001. The parametrization of the income process is similar to the parametrization used in other studies that consider a longer sample period (see, for instance, Aguiar and Gopinath (2006)). As in Arellano (2008), we assume that the probability of regaining access to capital markets (ψ) is 0.282.

With $\delta = 0.0341$, bonds have an average duration of 4.19 years in the simulations of the baseline model.[10] Cruces et al. (2002) report that the average duration of Argentinean bonds included in the EMBI index was 4.13 years in 2000. This duration is not significantly different

[10] We use the Macaulay definition of duration, which with the coupon structure assumed in this paper is given by

$$D = \frac{1 + r^*}{\delta + r^*},$$

where r^* denotes the constant per-period yield delivered by the bond.

from what is observed in other emerging economies. Using a sample of 27 emerging economies, Cruces et al. (2002) find an average duration of 4.77 years, with a standard deviation of 1.52.

We calibrate the discount factor, the income cost of defaulting (two parameter values), and the lenders' risk premium parameter to target four moments: A mean spread of 7.4 percent, a standard deviation of the spread of 2.5 percent, a mean public external debt to (annual) GDP ratio of 40 percent in the pre-default samples of our simulations (the exact definition of these samples is presented in Section 4.1), and a default frequency of three defaults per 100 years. The first three targets are computed using Argentine data from 1993 to 2001. Even though it is not obvious which value for the default frequency one should target, we include the default frequency as a target in our calibration because it has received considerable attention in the literature, it is clearly influenced by lenders' risk premium parameter, and it influences the welfare gains from the imposition of fiscal rules. We target a frequency of three defaults per 100 years because this frequency is often used in previous studies (see, for example, Arellano (2008) or Aguiar and Gopinath (2006)).[11]

4 Results

We first show that simulations of the benchmark economy fit the data reasonably well. Then, we study the optimality of a state-invariant debt-ceiling rule. We discuss (i) the welfare gains implied by this rule, (ii) the dynamics of the default probability, interest rate spread, and debt after the rule announcement, and (iii) the effects on the cyclicality of fiscal policy. We show how the value of previously issued debt appreciates upon the announcement of a rule, and discuss how the preferred rule depends on who appropriates those capital gains. Finally, we study the optimality of a cyclical debt-ceiling rule.

[11] Hatchondo et al. (2010b) show that the effects of debt dilution are similar in model economies with three and six defaults per 100 years. The discount factor value we obtain is relatively low but higher than the ones assumed in previous studies (for instance, Aguiar and Gopinath (2006) assume $\beta = 0.8$). Low discount factors may be a result of political polarization in emerging economies (see Amador (2003) and Cuadra and Sapriza (2008)).

	Data	Benchmark
$E(R_s)$	7.44	7.42
$\sigma\left(R_s\right)$	2.51	2.52
Mean debt-to-income ratio	0.40	0.39
Defaults per 100 years	3.00	2.99
$\sigma(\tilde{c})/\sigma(\tilde{y})$	0.94	1.23
$\rho\left(\tilde{c},\tilde{y}\right)$	0.97	0.99
$\rho\left(R_s,\tilde{y}\right)$	-0.65	-0.79

Table 2: Business cycle statistics. The second column is computed using data from Argentina from 1993 to 2001. The third column reports the mean value of each moment in 500 simulation samples. Each sample consists of 32 periods before a default episode. The default probability is computed using all simulation data.

4.1 Benchmark economy

Table 2 reports moments in the data and in the simulations of the benchmark model (without a rule).[12] As in previous studies, we report results for pre-default simulation samples. The exception is the default frequency, for which we use all simulated data. We simulate the model for a number of periods that allows us to extract 500 samples of 32 consecutive periods before a default. We focus on samples of 32 periods because we compare the data generated by the model with Argentine data from the fourth quarter of 1993 to the third quarter of 2001.[13]

The moments reported in Table 2 are chosen to illustrate the ability of the model to replicate distinctive features of business cycles in emerging economies. These economies present a high, volatile, countercyclical interest rate, and high consumption volatility. The interest rate spread (R_s) is expressed in annual terms. The logarithm of income and consumption are denoted by $\tilde{y}$ and $\tilde{c}$, respectively. The standard deviation of x is denoted by $\sigma\left(x\right)$ and is reported in

[12]The data for income and consumption is taken from the Argentine Finance Ministry. The spread before the first quarter of 1998 is taken from Neumeyer and Perri (2005), and from the EMBI Global after that. For the default frequency, we report the value we target, as discussed in Section 3.

[13]The qualitative features of these data are also observed in other sample periods and in other emerging markets (see, for example, Aguiar and Gopinath (2007), Alvarez et al. (2011), Boz et al. (2011), Neumeyer and Perri (2005), and Uribe and Yue (2006)). The only exception is that in the period we consider, the volatility of consumption is slightly lower than the volatility of income, while emerging market economies tend to display a higher volatility of consumption relative to income.

percentage terms. The coefficient of correlation between x and z is denoted by $\rho(x, z)$. Moments are computed using detrended series. Trends are computed using the Hodrick-Prescott filter with a smoothing parameter of $1,600$. Table 2 also reports the mean debt-to-income ratio, where the debt is calculated as $b/(\delta + r)$.

Table 2 shows that the baseline model matches the data reasonably well. As in the data, in the simulations of the baseline model consumption and income are highly correlated and the spread is countercyclical. Consumption volatility is higher than income volatility, which is consistent with the findings in Neumeyer and Perri (2005) and Aguiar and Gopinath (2007). The model also matches well the moments we targeted.

Figure 1 shows that fiscal policy is procyclical in the benchmark: Taxes tend to be higher (or transfers tend to be lower) when income is lower. This is consistent with the findings presented by Cuadra et al. (2010), who show that fiscal policy is procyclical in a sovereign default framework with a richer model of fiscal policy.

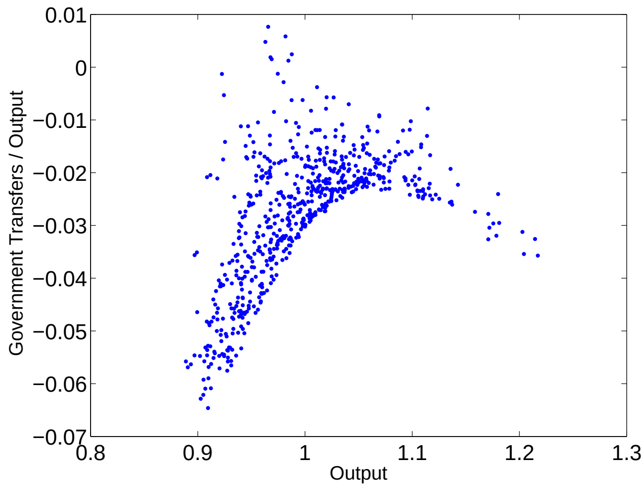

Figure 1: Income and government transfers in the simulations of the benchmark economy.

The intuition for the procyclicality of fiscal policy is the following: In bad times (output is low), the cost of borrowing is relatively high and the government chooses to finance more of its debt service obligations with taxes instead of new issuances. Figure 2 shows that the price at which the government can sell bonds is lower in bad times and that taxes tend to be higher when the sovereign interest rate spread is higher.

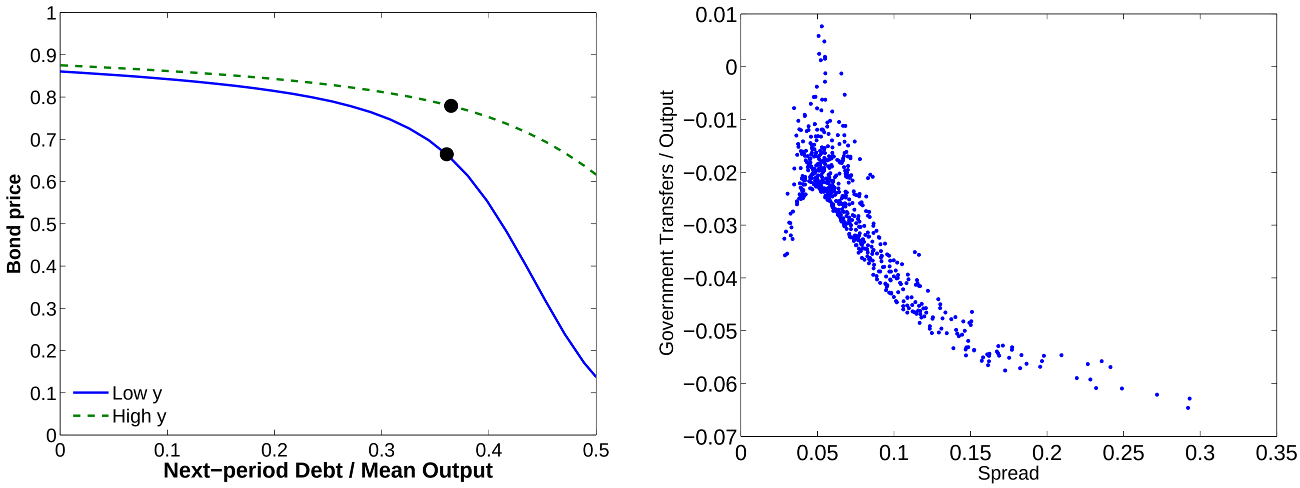

Figure 2: Borrowing cost and government transfers in the simulations of the benchmark economy. The left panel presents the menu of combinations of bond prices and next-period debt levels ($\frac{-b'}{\delta+r}$) from which the government can choose. Solid dots illustrate the optimal decision of a government that inherits a debt level equal to the average debt observed in the simulations. The low (high) value of y corresponds to an endowment realization that is one standard deviation below (above) the unconditional mean. The right panel presents spreads and government transfers in the simulations.

4.2 Optimal fiscal rule with a constant ceiling

We next find the optimal rule to be implemented in the benchmark no-rule economy. We first consider only rules that impose a debt ceiling that is not a function of aggregate income ($a_1 = 0$ in terms of equation (5)). In subsection 4.7 we study cyclically adjusted ceilings. We consider three pre-rule states characterized by a debt level of 38 percent of mean income and by different income levels, which determine the level of the sovereign spread. The relatively low-risk state has a spread of 5.1 percent, the normal-risk state has a spread of 7.4 percent, and the high-risk state with has spread of 15 percent.

Table 3 presents the optimal fiscal rule for each of the three states described above. The table shows that the level of pre-rule default risk does not significantly affect the rule to which the government would like to commit. Welfare is maximized with a debt ceiling of 30 percent of mean income and a delay of four years between the rule announcement period and the period in which the ceiling starts being enforced.

Announcement-period spread (pre announcement)	5.1%	7.4%	15.0%
Optimal debt ceiling (% of mean income)	30%	30%	30%
Optimal transition length (quarters)	18	17	17
Welfare gain	0.23%	0.23%	0.22%
Announcement-period spread (post announcement)	4.2%	6.0%	14.7%

Table 3: Optimal rules for pre-rule states with different sovereign spreads. The debt level is constant across pre-rule states (38 percent of mean income) but income levels differ.

4.3 Welfare gains

We measure welfare gains as the constant proportional change in consumption that would leave domestic consumers indifferent between continuing living in the benchmark economy (without a fiscal rule) and moving to an economy with a fiscal rule. Let V^{B} and V^{R} denote the value functions in the benchmark economy and an economy with a fiscal rule, respectively. The welfare gain of moving from the benchmark economy to an economy with a fiscal rule is given by

$$\left(\frac{V^{\mathrm{R}}(b,y)}{V^{\mathrm{B}}(b,y)}\right)^{\frac{1}{1-\gamma}} - 1.$$

For the three cases we study, the welfare gain from implementing the optimal rule is equivalent to a permanent increase in consumption of about 0.23 percent.

The government benefits from implementing a fiscal rule because the rule mitigates the debt dilution problem. A large literature discusses how, in the presence of default risk, the debt dilution problem implies that the government could benefit from a commitment to lower future debt levels (see Hatchondo et al. (2010b) and the references therein). Lower future debt levels imply lower future default probabilities that would allow the government to pay a lower spread when it issues debt. Figure 3 illustrates how the optimal rule may enable the government to pay a lower interest rate when it borrows. The next subsection presents a more detailed analysis of the default frequency, spread, and debt dynamics observed after the announcement of the optimal rule.

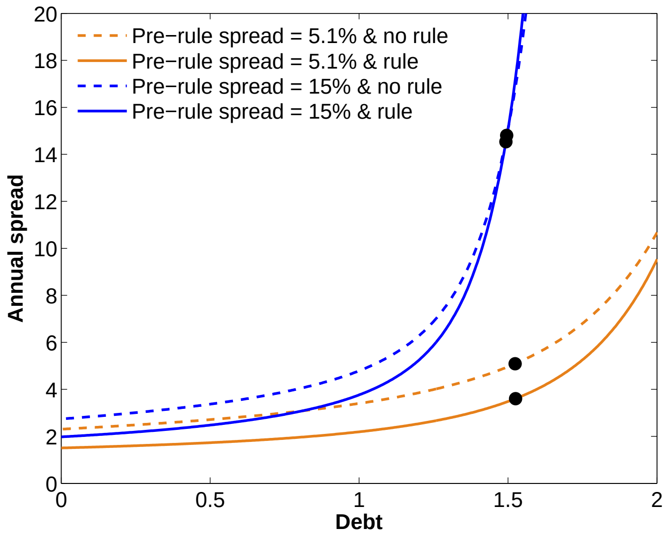

Figure 3: Menus of end-of-period debt $(-b'/(\delta + r))$ and spread, in the period in which the rule is announced (solid lines) and in an economy with no rules (dashed lines). Blue (orange) lines correspond to an income level for which the spread in the economy without a rule is 15 percent (5.1 percent), when the government starts the period with a debt level of 38 percent of mean income. Solid dots present the government's optimal choices for each case.

4.4 Default frequency, spread, and debt after the rule announcement

Figure 4 shows that in the periods that follow the optimal rule announcement, the default frequency is higher than what it would have been without a rule. This occurs because defaulting is one of the tools available to the government for reducing its debt level in order to meet the ceiling requirement. Only around the period when the debt ceiling starts being enforced is the default probability lower than in the no-rule economy.

Table 3 and Figure 3 show that, in spite of the higher default frequency in the periods that follow the optimal rule announcement, the spread may decline when the rule is announced. This occurs because (with long-term debt) the spread depends on all future default probabilities, and the effect on the spread of higher default probabilities during the first four years after the rule

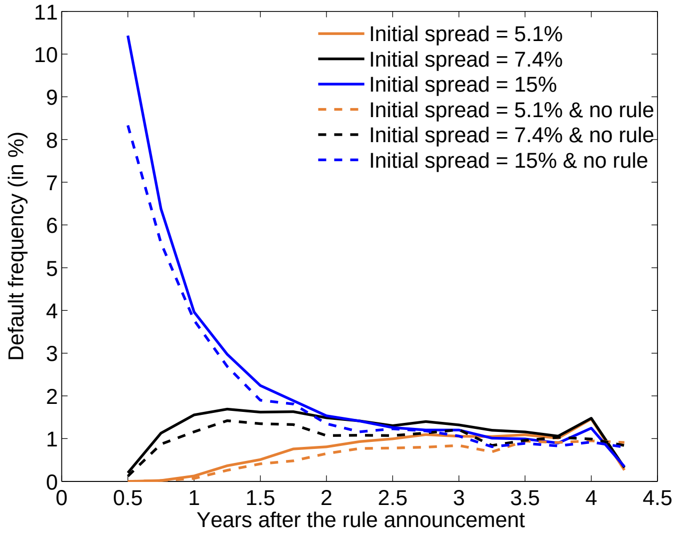

Figure 4: Default frequency during transitions that follow the announcement of the preferred rule.

announcement is more than offset by the effect of the lower default probabilities observed after that.

Figure 3 also shows that if the government were to choose to end the period with a sufficiently high stock of debt, the spread could actually be higher in the economy with a rule than in the no-rule benchmark. In those cases, the effect on the spread of higher default probabilities during the first four years after the rule announcement more than offset the effect of the lower default probabilities observed after that.

Figure 5 presents the mean debt and spread levels after the optimal rule announcement for transition paths in which the government does not default. The figure shows that after the announcement period, the spread is expected to decline faster when the pre-rule spread is higher. This explains why welfare gains from implementing the optimal rule are similar for the three cases considered in Table 3 despite a much lower announcement-period spread decline in the case with a 15 percent pre-rule spread.

Figure 5 also shows that the government chooses to delay the reduction in debt levels until the last year of the transition period. During the first three years, the government benefits from lower spreads without reducing its debt level by more than it would have without a rule.

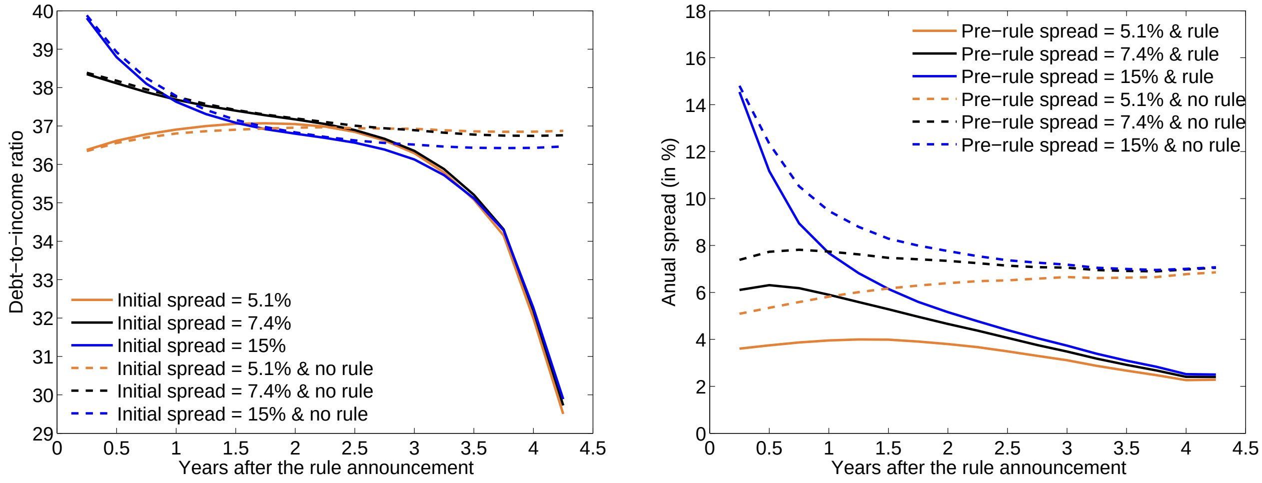

Figure 5: Mean debt-to-income ratio ($\frac{-b'/(\delta+r)}{4y}$) and interest rate spread during transitions that follow the announcement of the optimal rule for samples without defaults.

4.5 Fiscal rules and the cyclicality of fiscal policy

In this subsection, we discuss how lower debt levels implied by the imposition of a fiscal rule attenuates the procyclicality of fiscal policy. Recall that subsection 4.1 shows that fiscal policy is procyclical in the benchmark economy because in low-income periods the higher cost of issuing debt induces the government to finance more of its debt service obligations through tax revenues.

Table 4 shows that by reducing default risk, the optimal debt-ceiling reduces both the mean spread and the responsiveness of the spread to income shocks, which is reflected in a lower standard deviation of the spread. A cost of borrowing that is less responsive to income shocks dampens the driving force behind the procyclicality of fiscal policy. In turn, a less procyclical fiscal policy is reflected in a lower volatility of consumption relative to income. These findings support the consensus among policymakers regarding the desirability of targeting low sovereign debt levels to create room for the implementation of countercyclical fiscal policy (see, for instance, Blanchard et al. (2010)).

	No ceiling	35%	30%	25%	20%
Defaults per 100 years	2.99	2.86	1.33	0.42	0.09
$E(R_s)$	7.42	6.64	3.6	1.66	0.54
$\sigma(R_s)$	2.52	2.85	1.93	1.29	0.7
$\sigma(c)/\sigma(y)$	1.23	1.12	1.08	1.05	1.02

Table 4: Simulation results for different debt ceilings.

4.6 Fiscal rules and debt holders' capital gains

How would the choice of fiscal rule targets change if the government could benefit from the appreciation in the value of previously issued debt triggered by the implementation of a rule? Figure 6 illustrates how the spread in the announcement period and the welfare of domestic residents depend on the length of the transition period. The blue line shows that by choosing a shorter transition, the government could attain a larger reduction in the current spread. This would benefit holders of previously issued debt as they would experience a windfall gain (recall that the spread is a decreasing function of the bond price). But shorter transitions are costlier for the government because it cannot smooth out the cost of bringing down its debt level. This asymmetry raises a conflict of interest between the government and its creditors: Compared with the government, creditors prefer a shorter transition period and a lower debt ceiling.

In order to evaluate the importance of this conflict of interest, we assume the government extends a take-it-or-leave-it debt buyback offer promising that a rule will be implemented only if the offer is accepted. Thus, the government offers existing creditors to buy back previously issued bonds at the price that would have been observed if no rule is ever implemented. That price is lower than the post-rule price at which the government would be able to issue debt after implementing the rule (as illustrated in the right panel of Figure 5). This take-it-or-leave-it offer allows us to study the extreme case in which all capital gains created by the rule are reaped by the government. In previous subsections we studied the other extreme case in which the government does not benefit from these gains.

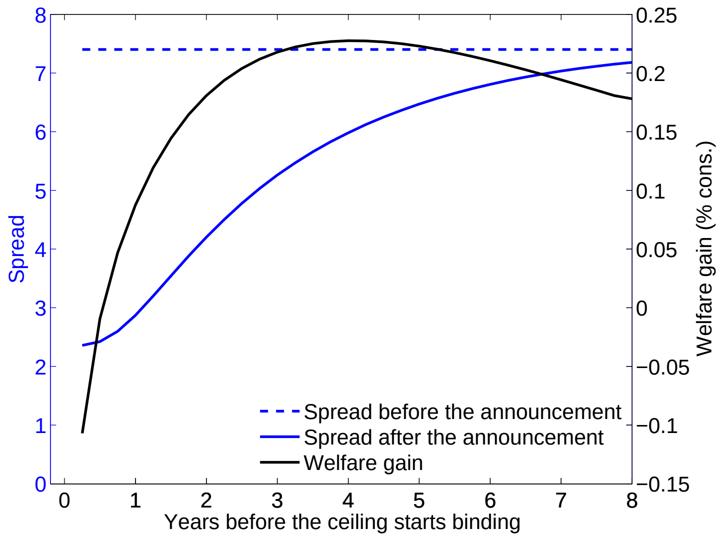

Figure 6: Spread after the implementation of a rule with a ceiling of 30 percent of mean income, when the debt is 38 percent of mean income and the pre-rule spread is 7.4 percent.

We find that when the government is the only one that benefits from the appreciation in the value of debt issued prior to the rule announcement, it chooses a lower debt ceiling with a shorter transition period. Table 5 shows that for the three pre-rule states we consider, the government chooses a 25 percent ceiling that is enforced less than two years after its announcement.

The exercise presented in this subsection can be thought of as a voluntary debt restructuring in which creditors accept a haircut in the nominal value of their debt claims while the market value

Announcement-period spread (pre announcement)	5.1%	7.4%	15.0%
Optimal debt ceiling (% of mean income)	25%	25%	25%
Optimal transition length (quarters)	7	6	3
Debt forgiveness	21%	25%	44%
Welfare gain	1.02%	1.29%	2.28%

Table 5: Optimal fiscal rules after a voluntary debt restructuring for pre-rule states with different sovereign spreads. These states have the same debt level (38 percent of mean income) and different income levels.

of these claims remains unchanged.[14] Table 5 shows that in exchange for the implementation of the optimal rule, lenders would accept a substantial haircut.

Table 5 also shows that when the pre-rule spread is higher, the government chooses shorter transition periods, and the welfare gain from implementing the optimal rule after a voluntary debt restructuring is larger. This is consistent with the larger debt forgiveness observed for higher pre-rule spread: Lower post-debt-exchange debt levels increases welfare and facilitate reducing indebtedness to a level consistent with the ceiling.

4.7 Cyclically adjusted fiscal rules

The analysis in this subsection allows us to shed light on the desirability of "escape clauses" that soften fiscal rules during recessionary periods. These clauses are commonly used in many countries (see IMF (2009)). Our findings serve as a warning against them.

We search for the optimal coefficients of rules like the ones specified in equation (5).[15] For simplicity, we only consider ceilings that will be enforced immediately by a government that currently does not have debt (since the initial debt is zero, there is no transition cost).

We find that the optimal rule is procyclical and imposes a limit on the debt-to-income ratio of 25 percent of annualized income ($a_1 = -1$ and $a_0 = 0$). Figure 7 shows that this rule implies a welfare gain equivalent to a permanent consumption increase of 0.63 percent.

Table 6 presents business cycle statistics from simulations of economies with rules that imply an average ceiling of 25 percent of mean income. The table shows that the preferred rule prioritizes lowering the default probability over reducing private consumption volatility: It leads to a

[14]We may overstate the benefits of a voluntary debt restructuring agreement because (i) we sidestep the cost of implementing such restructuring (see, for instance, Gulati and Zettelmeyer (2012)), (ii) we assume that there is no cost in terms of output or market access after the restructuring, and (iii) we assume that the government can credibly commit to not announce a fiscal rule in the future if its current debt exchange offer is not accepted. The objective of this subsection is not to evaluate an implementable policy but to illustrate how the choice of target values for fiscal rule would change if the government could appropriate the capital gains created by the rule.

[15]However, we still do not allow the government to issue income-indexed debt (see Bolton and Jeanne (2009), Borensztein and Mauro (2004), Durdu (2009), and Sandleris et al. (2011)). The overwhelming majority of sovereign debt bonds are not GDP-indexed in part because of verifiability and moral hazard issues that are not present in our stylized model. Furthermore, sovereigns' willingness to repay has many other determinants besides domestic income that, as most previous studies, we do not consider (Tomz and Wright (2007) argue that these other determinants play an important role as predictors of sovereign defaults). These issues could also make it difficult to establish contingent targets for fiscal rules.

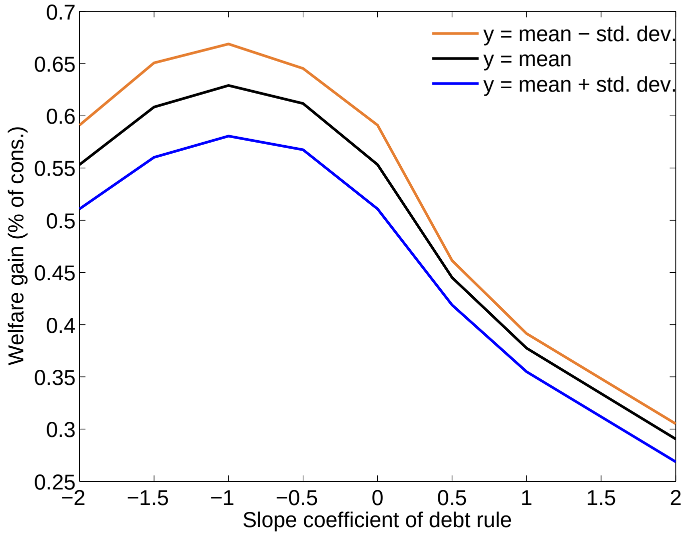

Figure 7: Welfare gain from implementing rules with an average debt ceiling of 25 percent of mean annual income and different slope coefficients.

frequency of 0.12 defaults every hundred years (instead of 3 in the no-rule benchmark and 0.42 with the acyclical ceiling) and to a standard deviation of consumption that is 48 percent higher than the standard deviation of income (instead of 23 percent higher in the no-rule benchmark and 5 percent higher with the acyclical ceiling).

Table 6 shows that if instead of choosing an acyclical ceiling ($a_1 = 0$), the government chooses countercyclical ceilings ($a_1 > 0$) that allow for higher debt levels in periods of lower income, there are no significant changes in consumption volatility. During low-income periods, the

Slope coefficient of debt ceiling rule	2	-1	-0.5	0	0.5	1	2
Defaults per 100 years	0.03	0.12	0.23	0.42	0.67	0.75	0.79
$E(R_s)$	0.10	0.68	1.07	1.66	2.13	2.41	2.63
$\sigma(R_s)$	0.03	0.55	0.85	1.05	1.43	1.41	1.47
$\sigma(c)/\sigma(y)$	1.82	1.48	1.25	1.05	0.98	1.04	1.05

Table 6: Simulation results with a debt ceiling $\underline{b}(y) = a_0 + a_1 y$, for different values of a_1, and values of a_0 such that the average ceiling is equivalent to 25 percent of mean annual income.

default probability becomes more sensitive to changes in debt levels. Therefore, a countercyclical ceiling that allows for more debt in those periods loosens the government's commitment to lower future default probabilities. This contributes to increase the level and countercyclicality of the government's borrowing cost, making it more difficult to conduct countercyclical fiscal policy.

For the parameterization considered in the paper, the government prefers a countercyclical ceiling only when the average debt implied by the rule is low enough that it eliminates default risk and, consequently, the countercyclicality of the borrowing cost. Those debt ceilings are below 10 percent of mean annual income and leave the government worse off compared with the no-rule benchmark.

5 Conclusions

We use a standard sovereign default framework to show how a government may benefit from implementing a debt ceiling rule. After the rule is announced, the expectation of lower future debt levels leads to substantial interest rate declines (bond prices increase). We show that the government chooses lower debt ceilings with shorter transition periods when it appropriates gains from the increase in the price of the bonds it has issued in previous periods. In addition, we demonstrate that after the imposition of a debt ceiling, lower debt levels allow the government to implement a less procyclical fiscal policy that reduces aggregate consumption volatility. However, the government prefers a procyclical debt ceiling that implies a larger reduction of the default probability at the expense of a higher aggregate consumption volatility.

We chose to make our analysis more transparent by respecting the simplifying assumptions commonly used in quantitative studies of sovereign defaults. Future work could enrich the analysis by relaxing these assumptions.

One interesting extension of the work presented here could be to study the impact of less-than-perfectly-credible fiscal rules. For instance, we abstract from political shocks that could threaten the enforcement of a rule (Alfaro and Kanczuk (2005), Amador (2003), Cole et al. (1995), Cuadra and Sapriza (2008), D'Erasmo (2008), and Hatchondo et al. (2009) study sovereign default models with political shocks). As in Chatterjee and Eyigungor (2012) and Hatchondo and Martinez (2009), we assumed that the government cannot choose the duration of its debt. Relaxing this assumption could enhance understanding of the effects of fiscal rules, but it would increase the computation cost substantially . [16] Extending our framework to include production could also improve the understanding of the effects of fiscal rules. Here, fiscal rules are found to have substantial effects on the level and volatility of interest rates. A number of studies find significant effects of the interest rate on productivity (through investment and the allocation of factors of production) and of interest rate fluctuations on the amplification of shocks (see, for example, Mendoza and Yue (2012), Neumeyer and Perri (2005), and Uribe and Yue (2006)). Since there is no production in our setup, it does not allow for these channels. Furthermore, our analysis of the cyclicality of fiscal policy is limited because fiscal policy does not play a role in stabilizing aggregate income. Studying a setup in which the sovereign simultaneously holds assets and liabilities might also be an interesting avenue for future research. Fiscal rules often aim at controlling the sovereign's accumulation of both assets and liabilities. For simplicity, as is standard in default models, we assume that the government cannot simultaneously have assets and liabilities (Alfaro and Kanczuk (2009) show that in a sovereign default model, the government typically does not choose to hold assets and liabilities simultaneously).

[16] In order to allow the government to choose a different duration of its debt, one would have to introduce bonds of different duration and keep track of how many of each of these bonds the government has issued (see Arellano and Ramanarayanan (2010)). Including additional state variables might also involve a significant computation cost (Hatchondo et al. (2010a) show that the computation cost of obtaining accurate solutions in default models may be significant, and Chatterjee and Eyigungor (2012) explain how the cost increases when long-duration bonds are assumed).

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