Fiscal rules and the sovereign default premium*

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Abstract

We use a sovereign default model to study the effects of introducing fiscal rules. A debt-brake (spread-brake) rule imposes a ceiling on the government budget balance with the objective of upholding sovereign debt (spread) levels below a limit. For a single model economy, similar welfare gains can be achieved with either a debt brake or a spread brake. However, for sets of heterogeneous economies, a common spread brake generates larger average welfare gains than a common debt brake. This suggests that when political constraints force common fiscal targets across countries, a common spread brake may be preferable over a common debt brake. Even if we could tailor fiscal rules to a single economy, a spread brake would be a better option when there is uncertainty about key characteristics of this economy and these characteristics may change over time.

JEL classification: F34, F41.

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1 Introduction

It is often recognized that fiscal policy frameworks lack an anchor to manage expectations about future policies, unlike frameworks used for monetary analysis, where such anchors play a key role (Leeper, 2010). Fiscal anchors could be useful to prevent the deficit bias that arises because of government myopia or time inconsistency problems in economies paying a sovereign default premium. Fiscal anchors could be particularly useful when deleveraging is needed and in periods of public debt expansions (as planned in some low-income and commodity-exporting countries). Bi et al. (2013) show that expectations about future fiscal consolidations are an important determinant of the success of fiscal adjustments. This paper argues that the sovereign default premium may be a better fiscal anchor than the debt level, studies the optimal value of fiscal anchors, and quantifies the effects of introducing fiscal rules that implement these anchors.

Fiscal rules are restrictions imposed (often in laws or in the constitution) upon the future governments' ability to conduct fiscal policy. Thus, fiscal rules could play a central role in managing expectations about future policies. Figure 1 shows that an increasing number of countries is adopting fiscal rules. The left panel of Figure 1 shows that the bulk of countries adopting fiscal rules are limiting the debt level. Most countries do this both directly with a debt limit and indirectly by constraining the budget balance.[1] The right panel of Figure 1 shows that many fiscal rules are supranational (perhaps the best-known example is the common sovereign debt limit imposed by the Maastricht Treaty), and that an increasing number of countries is establishing independent fiscal councils to improve compliance with their fiscal rules.

We evaluate fiscal rules in the light of a sovereign default framework à la Eaton and Gersovitz (1981) with long-term debt.[2] In this framework, a time consistency (debt dilution) problem generates a deficit bias that has been shown to be essential to generate plausible implications for

[1]Fiscal rules in Figure 1 impose at least one and often more than one numerical target. These targets may limit the level of debt, the budget balance, revenues, and expenditures.

[2]The Eaton and Gersovitz' (1981) framework is commonly used for quantitative studies of fiscal policy and sovereign debt crisis, see for instance Aguiar and Gopinath (2006), Arellano (2008), Cuadra and Sapriza (2008), D'Erasmo (2011), Durdu et al. (2013), Boz (2011), Lizarazo (2005, 2006), Pouzo and Presno (2013, 2014), Roch and Uhlig (2014), Sandleris et al. (2011) and Yue (2010). This framework is also used in studies of household default—see, for example, Athreya et al. (2007), Chatterjee et al. (2007), Hatchondo et al. (2015), Li and Sarte (2006), Livshits et al. (2008), and Sanchez (2010). Bi (2011) and Bi and Leeper (2012) present models of non-strategic default.

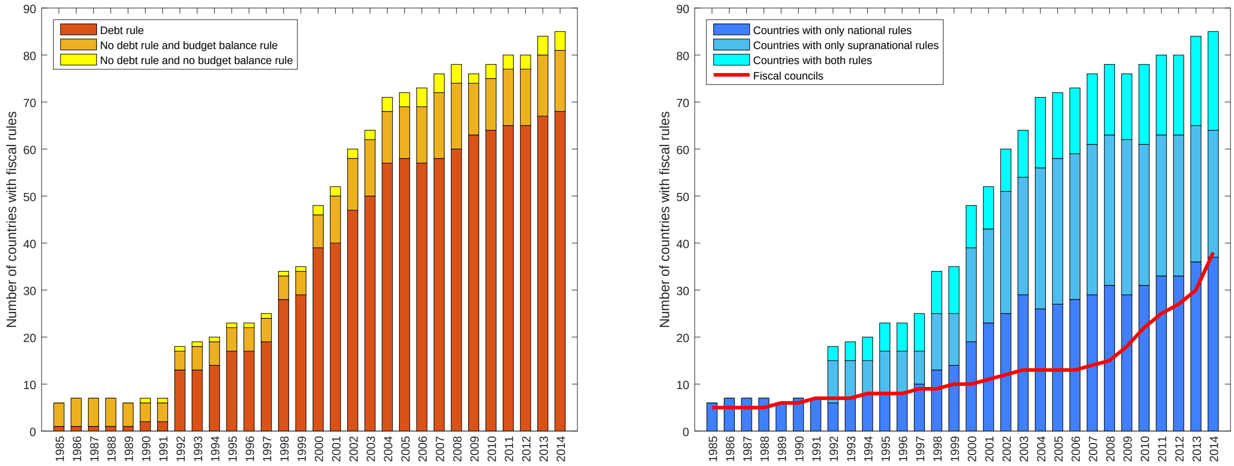

Figure 1: Number of countries with fiscal rules and fiscal councils. The left panel shows that most rules impose a limit on the debt level. The right panel shows the large number of countries with supranational rules and the increasing use of fiscal councils to enhance compliance with the rules in place. Source: IMF Fiscal Rules and Fiscal Councils datasets.

sovereign debt and the sovereign default premium (Chatterjee and Eyigungor, 2012; Hatchondo and Martinez, 2009; Hatchondo et al., forthcoming).[3] We assume aggregate output is determined by a total factor productivity (TFP) shock and labor-leisure decisions made by domestic households. The benevolent government finances the provision of a public good consumed by domestic households by levying labor taxes and issuing long-term defaultable debt. If the government defaults on its debt, it is excluded from credit markets for a stochastic number of periods, during which TFP is reduced.

Within this framework, we study fiscal rules that anchor expectations about future fiscal policy using either the level of sovereign debt or the default premium reflected in the sovereign spread (i.e., the difference between a sovereign bond yield and a risk-free interest rate). A debt-

[3]Debt dilution refers to the reduction in the value of existing debt triggered by the issuance of new debt. Issuing new debt reduces the value of existing debt because it increases the probability of default. Three factors generate the sovereign debt dilution problem: (i) governments issue long-term debt, (ii) the current government cannot control debt issuances by future governments, and (iii) bonds are priced by rational investors. Rational investors anticipate that additional borrowing by future governments will increase the risk of default on long-term bonds issued by the current government and, thus, offer a lower price for these bonds. The current government could benefit from constraining future borrowing because this could increase the price of the bonds it issues. However, governments are typically unable to constrain borrowing by future governments, which creates the debt dilution problem.

brake rule imposes a ceiling on the fiscal budget balance to prevent the sovereign debt level from exceeding a threshold. Similarly, a spread-brake rule imposes a ceiling on the fiscal budget balance such that the government cannot increase its debt level by borrowing at a sovereign spread above a threshold.

We first show how introducing a fiscal rule lowers sovereign risk and thus generates welfare gains. The fiscal rule limits future debt dilution and thus expands the government's borrowing set (i.e., it allows the government to sell the same level of debt at a higher price).

We then search for a common fiscal rule that maximizes welfare for a set of model economies with different levels of debt intolerance (i.e., different mappings from sovereign debt to the sovereign default premium).[4] Debt intolerance varies both across countries and over time (Reinhart et al., 2003; Reinhart et al., 2015). Searching for the best common fiscal rule for sets economies with different levels of debt intolerance is important for two reasons. First, fiscal rules often impose common limits to different economies (in the right panel of Figure 1, 48 of the 85 countries with fiscal rules in 2014 had supranational rules). More generally, international financial organizations often use common fiscal targets to guide policy advice.[5]

Second, policy recommendations should acknowledge that economies may change over time making it difficult to identify the level of debt intolerance. For instance, the implementation of structural reforms may increase confidence in the future repayment of debt obligations, reducing debt intolerance. Thus, identifying the level of debt intolerance in a particular country and period may be difficult (for instance, what is the relationship between the levels of sovereign debt and spreads that will prevail in Greece after the crisis?). Structural changes introduce a

[4]We also study sets of model economies that differ in the government's eagerness to borrow and thus in its willingness to pay high spreads in equilibrium. One could think that since these economies present a larger range of spread levels, they could present a bigger challenge for a common spread brake. We show that this is not the case.

[5]The IMF is bounded by the principle of uniformity of treatment, according to which the treatment of members must remain equal and comparable, allowing for no preferences in favor of any country or group of countries. For instance, the IMF 2014 Reform of the Policy on Public Debt Limits in Fund-Supported Programs states that "The reform proposal seeks to accommodate a number of concerns emphasized by Executive Directors and other stakeholders, including: (i) ensuring even-handedness across the membership in the application of the policy, consistent with the principle of uniformity of treatment" (IMF, 2014). Common sovereign debt thresholds are also used across countries by the IMF, as one of the criteria for deciding on the level of scrutiny to be applied in surveillance (IMF, 2013b; IMF, 2013c).

tension in the design of fiscal rules. On the one hand, an effective fiscal rule requires stable fiscal anchors that are not too easy to modify. On the other hand, we would like rules to accommodate for structural changes. Our discussion of common fiscal rules that maximize welfare for sets of heterogeneous economies sheds light on which rules could be stable while still accommodating structural changes and uncertainty about structural parameters.

We find that for sets of economies with different levels of debt intolerance, the optimal common spread brake generates a larger average welfare gain than the optimal common debt brake. This is the case even when, for each economy in the set, idiosyncratic spread and debt brakes tailored for that economy would deliver the same welfare gain. This result is intuitive. Recall that gains from imposing a fiscal rule arise because the rule achieves a reduction in sovereign risk. A debt brake is too blunt of an instrument for that goal. For economies with high debt intolerance, a debt limit that is too loose fails to achieve the desired risk reduction. For economies with low debt intolerance, a debt limit that is too tight may unnecessarily prevent a government from borrowing. This makes it difficult to use a debt limit as a common and robust target for a fiscal rule. Our results are consistent with empirical analysis documenting the impossibility of finding common debt thresholds across countries for the relationship between debt levels and long-run growth (Eberhardt and Presbitero, 2015). In contrast, since the sovereign spread incorporates information about the degree of debt intolerance in each economy, a common spread brake forces economies with more debt intolerance to borrow less while allowing economies with less debt intolerance to borrow more.

We also show that in the quantitative exercise, commitment to the optimal spread brake is not an issue: the government would never want to abandon the optimal spread brake (if abandoning this fiscal rule implies returning to the equilibrium without a fiscal rule). While abandoning the optimal spread brake may allow the government to increase its level of indebtedness, potential gains from doing so are eliminated by the higher interest rate the government has to pay in the no-rule equilibrium.

In addition, we show that even though the limited commitment friction could be eliminated by a rule that does not allow for defaults, the enforcement needed to prevent deviations from this rule would be significant: the gain from abandoning this rule may represent up to 12 percent of annual output. We also show that the advantages of a common spread brake are robust to introducing into the baseline model a global shock that affects bondholders' risk aversion and thus the spread.

Our findings highlight significant limitations to the widespread use of debt limits as fiscal anchors. Debt limits are often at the center of debates on sovereign debt deleveraging and the bulk of countries adopting fiscal rules are limiting the debt level (left panel of Figure 1). While there is consensus among policymakers on the desirability of fiscal rules targeting lower sovereign debt levels, significant uncertainty remains about the optimal value of debt targets. More generally, while optimal sovereign debt levels are often at the center of policy debates, these debates are rarely guided by economic theory.[6] For example, a former IMF chief economist asked: "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?" (Blanchard, 2011).

Our findings suggests that the unstable relationship between sovereign debt levels and sovereign risk provides a rationale to shift the focus of fiscal policy discussions from setting objectives for debt levels to setting objectives for sovereign spreads. Maybe we should ask what levels of sovereign premium countries should target, instead of asking what levels of public debt they should aim for.

While policy debates are often centered around sovereign debt levels, interest rates also play a role in these debates, and this role is growing. For instance, concerns about sovereign spreads vis-à-vis Germany guided the fiscal consolidation in Sweden in the 1990s (Henriksson, 2007). Debrun and Kinda (2013) find that the high interest rate bills trigger fiscal adjustments. Claessens et al. (2012) argue that the challenge is to complement fiscal rules affecting quantities most productively with market-based mechanisms using price signals. Juvenal and Wiseman (2015) use the sovereign spread to evaluate Portugal's fiscal position. Recent revisions of the IMF fiscal sustainability framework incorporate sovereign spreads as an additional criterion to guide the

[6]The IMF flagship fiscal publication has recently stated that "the optimal-debt concept has remained at a fairly abstract level, whereas the safe-debt concept has focused largely on empirical applications" (IMF, 2013a), where safe debt levels are those less correlated with the occurrence of crises.

level of scrutiny in surveillance (IMF, 2013b).[7] Consiglio and Zenios (2015) advocate the use of the average sovereign CDS spread to trigger the suspension of payment of sovereign contingent debt (see also Barkbu et al., 2012).

Of course, several issues need to be considered for the successful use of sovereign spreads to anchor expectations about future fiscal policy. We envision a spread-brake fiscal rule imposing a ceiling on the fiscal budget balance when the sovereign spread is above a threshold. Thus, the spread brake would work similarly to popular debt-brake rules imposing a ceiling on the balance when the sovereign debt level is higher than a threshold (for instance, in the 2011 reform of the Maastricht Treaty). The spread-brake threshold could be compared with the average spread over a longer period (for example previous fiscal years) to avoid reactions to short-term fluctuations in spread (the use of a "cooling off" period before sovereign spreads trigger sovereign debt covenants is suggested, for instance, by Barkbu et al., 2012).[8] Measures of the domestic component of the spread (Juvenal and Wiseman, 2015) could be used to avoid reactions to changes in global factors. To avoid a bias towards procyclical fiscal policy, spreads brake could limit only the budget balance during economic booms, as debt brakes do in practice. Emphasizing the sovereign spread as a fiscal anchor would underscore the importance of having a sovereign interest rate freely determined in a liquid market that does not reflect the expectation of inefficient bailouts. Of course, not every country has such a rate.

1.1 Related Literature

Some 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) and Kumhof and Laxton (2013) measure gains from implementing fiscal rules that stipulate countercyclical fiscal policies. Medina and Soto (2007) use a model of the Chilean economy to show how

[7] We complement the sustainability analysis (Adler and Sosa, 2013; Ghosh et al., 2011; Tanner and Samaké, 2006) commonly used in policy circles (see, e.g., IMF, 2013c, and IMF Article IV country reports) by modeling endogenous sovereign spreads (that, for example, capture the effects of the expectation of future fiscal adjustments), a welfare criterion, and optimal borrowing policies (that react to fiscal rules).

[8] In the model, in order to economize a state variable (and without compromising the tradeoffs we want to highlight), instead of using the average spread over previous periods, we use the spread level implied by the fiscal balance.

a fiscal rule mitigates the macroeconomic effects of copper-price shocks. 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) argue that debt limits may be preferable over constraints on the government's deficit. These studies do not discuss common fiscal rule limits for sets of different economies, which is the main focus of our analysis. Furthermore, these studies abstract from the effects of the expectation of future indebtedness on the sovereign premium, which we show can be key for understanding gains from imposing fiscal rules.

An extensive literature discusses the importance of the sovereign debt dilution problem. We show that fiscal rules mitigate this problem. Chatterjee and Eyigungor (forthcoming) and Hatchondo et al. (forthcoming) discuss the quantitative effects of modifying sovereign debt contracts to deal with the dilution problem. Chatterjee and Eyigungor (forthcoming) study the effects of introducing a seniority structure, and Hatchondo et al. (forthcoming) study the effects of introducing debt covenants that penalize future borrowing.

We see these proposals for dealing with dilution as complementary and the study of these complementarities as an interesting avenue for future research. In particular, Hatchondo et al. (forthcoming) study sovereign debt covenants that increase bond payments when either the debt level or the sovereign spread are above a threshold. These covenants could be useful to enhance commitment to the fiscal rules studied in this paper. We demonstrate the advantage of spread thresholds over debt thresholds when a unique threshold is imposed to several economies (or there is uncertainty about the level of debt intolerance in one economy), which Hatchondo et al. (forthcoming) do not discuss. Our results could inform the design of the debt covenants presented by Hatchondo et al. (forthcoming).

A key difference between fiscal rules and seniority is that rules lower the level of indebtedness while seniority increases it. In fact, Chatterjee and Eyigungor (forthcoming) report that the majority of the welfare gain obtained with seniority is due to the resulting increase of indebtedness. However, the default model favors higher indebtedness because it omits political myopia (the importance of political myopia is highlighted by Amador, 2012; Azzimonti, 2011; Azzimonti et al., 2010; Cole et al., 1995; Cuadra and Sapriza, 2008; Halac and Yared, 2014, 2015; and

Hatchondo et al., 2009). We show that the optimal debt limit decreases with the degree of political myopia. Thus, political myopia may present an important challenge for policy prescriptions that increase the level of indebtedness, as seniority does. In contrast, introducing differences in political myopia strengthens our results. We show that economies with more political myopia (proxied by an index of political risk) typically display more debt intolerance. Therefore, these economies require lower debt limits. Applying such lower debt limits to economies with less debt intolerance and less myopia would not be desirable. However, countries with different degrees of myopia could benefit from a common spread brake.

Halac and Yared (2015) extend their model of governments' deficit bias and fiscal rules (Halac and Yared, 2014) to a multicountry setting in which a supranational fiscal rule affects the global interest rate. Fiscal rules can also play a role in a monetary union because of political economy considerations (Beetsma and Uhlig, 1999) or time inconsistency problems (Chari and Kehoe, 2007). In this paper, we abstract from the effects of fiscal rules on the global interest rate and on monetary policy. Instead, we argue that due to empirically relevant differences in debt intolerance among countries, a supranational spread rule is preferable over a supranational debt rule.

As we do, Calvo (1988) discuses gains from introducing interest-rate limits for sovereign debt. However, there are important differences between the two analyses. In Calvo's (1988) model, an interest-rate limit is used to eliminate bad equilibria in a multiple-equilibria framework. Calvo (1988), and more recently, Lorenzoni and Werning (2014) assume that first the government determines the proceeds from debt issuances it needs, and later, lenders choose what interest rate they ask for to finance the government's needs. Since higher debt levels imply more default risk and thus higher interest rates, government's needs can be financed in either a good, low-debt, low-rate equilibrium or a bad, high-debt, high-rate equilibrium. An interest-rate limit eliminates the possibility of a bad equilibrium. In contrast, we assume that the government chooses the level of debt it wants to issue (instead of the proceeds from debt issuances), eliminating the possibility of a bad equilibrium à la Calvo-Lorenzoni-Werning. While we do no study multiple equilibria, eliminating bad equilibria à la Calvo-Lorenzoni-Werning could present additional gains from establishing spread rules.

The paper also contributes to the discussion of the optimal cyclicality of fiscal policy. Cuadra et al. (2010) show that in a sovereign default model with one-period debt and without a fiscal rule, it is optimal for the government to borrow less when income is low. Thus, the optimal fiscal policy is procyclical. We show that the same is true in our model with long-term debt. This is consistent with the procyclical fiscal policy observed in emerging economies (Végh and Vuletin (2011)). We also show that in the presence of sovereign risk, if the government can limit future policy choices with a fiscal rule, it may still not want to use the rule to promote countercyclical policies.

The rest of the article proceeds as follows. Section 2 presents a three-period model that illustrates how a benevolent government may benefit from a fiscal rule and how, when applied to a set of heterogeneous economies, a common spread brake may outperform a common debt brake. Section 3 introduces the quantitative model. Section 4 discusses the calibration. Section 5 presents simulation results for the benchmark model without a fiscal rule. Section 6 presents the optimal debt and spread brakes for the benchmark economy and discusses commitment to the optimal rule. Section 7 shows that a spread brake is a better common rule for sets of heterogeneous model economies. Section 8 shows that welfare gains from introducing fiscal rules are larger when we assume political myopia. Section 9 incorporates a global factor that affects the sovereign premium and shows that a common spread brake continues to outperform a common debt brake. Section 10 shows that even when the government limits future policy choices with a fiscal rule, it may not want to use this rule to promote a countercyclical policy. Section 11 discusses the gains from introducing a fiscal rule for economies that need to reduce the debt level. Section 12 shows that a no-default fiscal rule may be difficult to enforce. Section 13 concludes.

2 A three-period model

This section presents a simple model in which the sovereign spread is only a function of the debt level chosen by the government and the level of debt intolerance in the economy. We use this model to illustrate how the introduction of fiscal rules generates welfare gains and how a common spread brake outperforms a common debt brake. The next sections expand this simple environment in several dimensions and show that richer models produce the same results.

2.1 Environment

The economy lasts for three periods, $t = 1, 2, 3$. The government receives a sequence of endowments, given by $y_1 = y_2 = 0$, and $y_3 > 0$. The only uncertainty in the model is about the value of y_3. Let F and f denote the c.d.f. and density functions of y_3, with $f(y_3) > 0$ for all y_3. The government makes its decisions on a sequential basis and maximizes $u(c_1) + u(c_2) + \beta \mathbb{E}[u(c_3)]$, where the utility function u is increasing and concave, c_t represents period-t consumption, $\beta \leq 1$ denotes the factor with which the government discounts period 3 consumption, and $\mathbb{E}$ denotes the expectation operator.

The government can borrow to finance consumption in periods 1 and 2. A bond issued in period 1 promises to pay δ unit of the good in period 2 and $(1 - \delta)$ units in period 3. Thus, if $\delta = 1$, the government issues one-period bonds in period 1. If $\delta < 1$, the government issues long-term bonds in period 1. A bond issued in period 2 promises to pay one unit of the good in period 3.

The government may choose to default in period 3.[9] If the government defaults, it does not pay its debt but looses a fraction ϕ of the period-3 endowment y_3. It should be noted that none of the results reported in this section depend on the strategic-default assumption. The same results would be obtained by assuming that the government can only pay a fraction ϕ of period-3 income and defaults whenever it cannot pay its debt obligations. Bonds are priced by competitive risk-neutral investors who discount future payments at a rate of 1.

Let b_t denote the number of bonds issued by the government in period t and q_t the price at which the government sells these bonds. The budget constraints are:

$$
\begin{aligned}
c_1 &= b_1 q_1(b_1, b_2), \\
c_2 &= b_2 q_2(b_1, b_2) - \delta b_1, \qquad (1) \\
c_3 &= y_3(1 - d\phi) - (1 - d)[b_1(1 - \delta) + b_2],
\end{aligned}
$$

[9]In period 2, since no new information is revealed, there cannot be a meaningful default decision.

where d denotes the government's default decision and is equal to 1 if the government defaults and to 0 otherwise.

2.2 Optimal fiscal rules for a single economy

In this setup, it is optimal to borrow because the government has no income in the first two periods ($y_1 = y_2 = 0$) and is impatient ($\beta \leq 1$). However, the borrowing choices available to the government are restricted by a limited commitment problem.

The equilibrium default decision is given by

$$\hat{d}(b_1, b_2, y_3) = \begin{cases} 1 & \text{if } y_3 < \frac{b_1(1-\delta)+b_2}{\phi}, \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

Given the above defaulting rule, the price of a bond issued in period 1 is given by

$$q_1(b_1, b_2) = \delta + (1-\delta)\left[1 - F\left(\frac{b_1(1-\delta)+b_2}{\phi}\right)\right]. \tag{3}$$

The price of a bond issued in period 2 is given by

$$q_2(b_1, b_2) = 1 - F\left(\frac{b_1(1-\delta)+b_2}{\phi}\right). \tag{4}$$

Since the government does not borrow in period 3, there is no role for rules that limit the government behavior in that period. It is easy to verify that there is also no role for rules in period 1. Proposition 1 shows that when the government can only issue one-period debt, there is no role for fiscal rules in period 2.

Proposition 1 *Suppose $\delta = 1$; i.e., bonds issued in period 1 pay off in period 2 alone. Then, the government's expected utility in period 1 cannot be improved with a fiscal rule that limits debt choices in period 2.*

Proof: *Let $\{b_1^*, b_2^*\}$ denote the sequence of borrowing that maximizes the government's expected utility in period 1. This sequence satisfies*

$$u'(c_1^*) = u'(c_2^*) = \frac{\beta \mathbb{E}\left[u'(c_3^*)\left[1-\hat{d}(b_1^*, b_2^*, y_3)\right]\right]}{q_2(b_1^*, b_2^*) + b_2^* \frac{\partial q_2(b_1^*, b_2^*)}{\partial b_2}},$$

where

$$c_1^* = b_1^* q_1(b_1^*, b_2^*),$$

$$c_2^* = b_2^* q_2(b_1^*, b_2^*) - \delta b_1^*,$$

$$c_3^* = y_3[1-\hat{d}(b_1^*, b_2^*, y_3)\phi] - [1-\hat{d}(b_1^*, b_2^*, y_3)]b_2^*.$$

In period 2, the government's optimal choice satisfies

$$u'(c_2) = \frac{\beta \mathbb{E}\left[u'(c_3)\left[1-\hat{d}(b_1, b_2, y_3)\right]\right]}{q_2(b_1, b_2) + b_2 \frac{\partial q_2(b_1, b_2)}{\partial b_2}}.$$

Thus, when decisions are made on a sequential basis, if the government acting in period 1 chooses b_1^*, it is expected that the government acting in period 2 will choose b_2^*. This means that the government's expected utility in period 1 cannot be improved with a fiscal rule limiting the government's choices in period 2.

Proposition 2 shows that a role for fiscal rules arises when the government issues long-term debt (in period 1).

Proposition 2 *Suppose $\delta < 1$; i.e., the government issues long-term debt in period 1. Then, a fiscal rule limiting the government's choices in period 2 is needed to maximize the government's expected utility in period 1.*

Proof: *Let $\{b_1^*, b_2^*\}$ denote the sequence of borrowing that maximizes the government's expected utility in period 1. This sequence satisfies*

$$u'(c_1^*)\left[q_1(b_1^*, b_2^*) + b_1^* \frac{\partial q_1(b_1^*, b_2^*)}{\partial b_1}\right] = u'(c_2^*)\left[\delta - b_2^* \frac{\partial q_2(b_1^*, b_2^*)}{\partial b_1}\right] + \beta(1-\delta)\mathbb{E}\left[u'(c_3^*)\left[1-\hat{d}(b_1^*, b_2^*, y_3)\right]\right], \tag{5}$$

$$u'\left(c_2^*\right)\left[q_2(b_1^*,b_2^*)+b_2^*\frac{\partial q_2(b_1^*,b_2^*)}{\partial b_2}\right]=\beta\mathbb{E}\left[u'\left(c_3^*\right)\left[1-\hat{d}(b_1^*,b_2^*,y_3)\right]\right]-\mathbf{u}'\left(\mathbf{c_1^*}\right)\mathbf{b_1^*}\frac{\partial \mathbf{q_1}(\mathbf{b_1^*},\mathbf{b_2^*})}{\partial \mathbf{b_2}}. \quad (6)$$

The government's optimal choice when it maximizes its expected utility in period 2 satisfies

$$u'\left(c_2\right)\left[q_2(b_1,b_2)+b_2\frac{\partial q_2(b_1,b_2)}{\partial b_2}\right]=\beta\mathbb{E}\left[u'\left(c_3\right)\left[1-\hat{d}(b_1,b_2,y_3)\right]\right]. \quad (7)$$

The second term in the right hand side of equation (6) represents the marginal cost that borrowing in period 2 imposes on consumption in period 1. While a government choosing a borrowing sequence in period 1 would internalize the effect of borrowing in period 2 on consumption in period 1, this effect does not influence the decision of the government choosing in period 2 (equation 7). Since the second term in the right hand side of equation (6) is positive, when decisions are taken on a sequential basis, the allocation that maximizes the government's expected utility in period 1 cannot be attained without a fiscal rule (if the government acting in period 1 chose b_1^*, the government acting in period 2 will not choose b_2^*).

In contrast, the allocation that maximizes the government's expected utility in period 1 can trivially be attained with a fiscal rule that forces the period 2 government to choose b_2^* (with the period 1 government choosing b_1^*).

The role for a fiscal rule arises because the rule eliminates the debt dilution problem. With long-term debt, period 2 debt issuances dilute the price of period 1 debt (only with long-term debt $q_1(b_1, b_2)$ is decreasing with respect to b_2 in equation 3). The allocation that maximizes the government's expected utility in period 1 takes into account that the price of the debt issued in period 1 is negatively affected by debt issuances in period 2 (last term of the right-hand side of equation 6). But this is not a cost for the sequential government acting in period 2 (equation 7). Consequently, in the absence of a fiscal rule, from the perspective of the government acting in period 1, the government acting in period 2 overborrows and thus exposes the government acting in period 1 to excessive default risk (the optimal default rule in equation 2 implies that the default probability is increasing with respect to b_2).

It should be noted that instead of using a fiscal rule, the government could simply implement the optimal allocation by choosing to issue one-period bonds in period 1. This is only the case because we assume there is no rollover risk in period 2 (i.e., we assume there are no shocks to the government's borrowing opportunities in period 2). With plausible rollover risk, the government needs to issue long-term debt and thus a fiscal rule would be useful for mitigating the debt dilution problem. Arellano and Ramanarayanan (2012), Hatchondo and Martinez (2013), and Hatchondo et. al. (forthcoming) present models of sovereign default and endogenous debt maturity in which plausible calibrations of rollover risk deliver debt maturities observed in the data in spite of the debt dilution problem. For simplicity, we abstract from rollover risk and assume an exogenous debt maturity.

We study two ways of imposing a limit on government's choices in period 2. A debt-brake rule imposes a ceiling on the debt level, $(1-\delta)b_1 + b_2 \leq \bar{b}$. A spread-brake rule imposes a ceiling on the spread paid by the government and thus a floor on the sovereign bond price, $q_2(b_1, b_2) \geq \underline{q}$. Proposition 3 states that for a single economy, there is an equivalence between debt and spread brake rules. In contrast, the next subsections show that, as the common fiscal rule for a set of heterogeneous economies, a spread brake performs better than a debt brake.

Proposition 3 *The allocation that maximizes the government's expected utility in period 1 can be attained by limiting the government choices in period 2 with either a debt brake with threshold $\bar{b}^* = (1-\delta)b_1^* + b_2^*$ or a spread brake with threshold $\underline{q}^* = q_2(b_1^*, b_2^*)$.*

Proof: *Since $f(y_3) > 0$ for all y_3, q_2 is a strictly decreasing function of b_2. Therefore, for a government that chooses b_1^*, imposing the spread brake threshold $\underline{q}^* = q_2(b_1^*, b_2^*)$ is equivalent to imposing the debt brake threshold $\bar{b}^* = b_1^* + b_2^*$. Since*

$$u'\left(c_2^*\right)\left[q_2(b_1^*, b_2^*) + b_2^* \frac{\partial q_2(b_1^*, b_2^*)}{\partial b_2^*}\right] > \beta \mathbb{E}\left[u'\left(c_3^*\right)\left[1 - \hat{d}(b_1^*, b_2^*, y_3)\right]\right],$$

with either a debt brake with threshold $\bar{b}^* = b_1^* + b_2^*$ or a spread brake with threshold $\underline{q}^* = q_2(b_1^*, b_2^*)$, if the government chose b_1^* in period 1, the government chooses b_2^* in period 2. Anticipating this, the government chooses b_1^* in period 1 to maximize its expected utility.

2.3 Optimal common fiscal rule for a set of heterogeneous economies

While for any single economy the same welfare gain can be obtained with either a debt brake or a spread brake (Proposition 3), we next show that for any set of heterogenous economies indexed by the value of the parameter $\theta \in \{\phi, \beta\}$, a common spread brake may outperform a common debt brake. Let $h(\theta)$ represent the density function for θ in this set. Let $v(x;\theta)$ denote the expected utility in period 1 in an economy with parameter θ, and a fiscal rule with threshold x. We define the optimal common fiscal rule threshold X^* as the one that maximizes

$$\max_x \int v(x;\theta)h(\theta)d\theta.$$

There are two interpretations of the optimal common fiscal rule threshold X^*. First, X^* is the threshold that would be chosen by a planer implementing a fiscal rule for a set of different economies while giving weight $h(\theta)$ to economies with parameter value θ. Second, X^* is the threshold that would be chosen by a planer implementing a fiscal rule in a single economy when the planer is uncertain about the value of the parameter θ and assigns the likelihood $h(\theta)$ to θ.

2.3.1 Optimal common fiscal rule and debt intolerance

We first focus on sets of economies with different levels of debt intolerance, as given by the cost of defaulting ϕ (economies with a lower cost of defaulting display more debt intolerance, i.e., pay a higher spread for lower debt levels; see equations 3 and 4). The next proposition illustrates the advantage of a common spread brake over a common debt brake. A common debt-brake rule imposes to all economies in the set a common ceiling $(1-\delta)b_1 + b_2 \leq \bar{B}$ in period 2. A common spread-brake rule imposes to all economies in the set a common ceiling on the spread paid by the government and thus a floor on the sovereign bond price, $q_2(b_1, b_2) \geq \underline{Q}$. The proposition presents sufficient conditions under which, for any set of economies with different levels of debt intolerance, the optimal common spread-brake threshold $\underline{Q}^*$ delivers the same welfare gains the optimal idiosyncratic fiscal rule customized for each economy in the set would deliver. Since this is something that a common debt-brake threshold $\bar{B}$ could never achieve, the optimal common spread brake delivers larger welfare gains than any common debt brake. These results require the following assumption:

Assumption 1: The function

$$\zeta_q(b) = \frac{bf(b)}{\phi[1 - F(b)]}$$

is increasing with respect to b and $\lim_{b\to\infty} \zeta_q(b) \geq 1$.

The function ζ_q is the absolute value of the elasticity of the bond price with respect to the debt level. Thus, Assumption 1 states that the bond price is more responsive to changes in the debt level for higher debt levels. In the next proposition, this is a sufficient condition for the existence of a unique optimal fiscal rule for each level of debt intolerance (as determined by the cost of defaulting parameter ϕ).

Proposition 4 *Suppose $\delta = 0$, $u(c) = c$, and Assumption 1 holds. Then, for any economy with cost of defaulting ϕ, the optimal debt brake threshold is $\bar{b}^* = \eta\phi$ and the optimal spread brake threshold is $\underline{q}^* = 1 - F(\eta)$, with $\eta > 0$. Therefore, for any set of economies with different values of ϕ, the optimal common spread-brake threshold is $\underline{Q}^* = 1 - F(\eta)$, and generates larger welfare gains than any common debt-brake threshold $\bar{B}$.*

Proof: *With $\delta = 0$, the default decision and bond prices are functions of the sum of bonds issued in the first two periods ($b_1 + b_2$; see equations 2, 3 and 4). Furthermore, the bond price functions for periods 1 and 2 are identical:*

$$q_1(b_1, b_2) = q_2(b_1, b_2) = 1 - F\left(\frac{b_1 + b_2}{\phi}\right).$$

Therefore, equations (5) and (6), which determine the borrowing sequence $\{b_1^*, b_2^*\}$ that maximizes the government's expected utility in period 1, can be written as:

$$u'(c_1^*)\left[1 - F\left(\frac{b_1^* + b_2^*}{\phi}\right) - \frac{b_1^*}{\phi} f\left(\frac{b_1^* + b_2^*}{\phi}\right)\right] - u'(c_2^*)\frac{b_2^*}{\phi} f\left(\frac{b_1^* + b_2^*}{\phi}\right) = \beta \mathbb{E}\left[u'(c_3^*)\left[1 - \hat{d}(b_1^*, b_2^*, y_3)\right]\right], \tag{8}$$

$$u'(c_2^*)\left[1 - F\left(\frac{b_1^* + b_2^*}{\phi}\right) - \frac{b_2^*}{\phi} f\left(\frac{b_1^* + b_2^*}{\phi}\right)\right] - u'(c_1^*)\frac{b_1^*}{\phi} f\left(\frac{b_1^* + b_2^*}{\phi}\right) = \beta \mathbb{E}\left[u'(c_3^*)\left[1 - \hat{d}(b_1^*, b_2^*, y_3)\right]\right]. \tag{9}$$

Equations (8) and (9) imply that $c_1^* = c_2^*$ *and thus* $b_1^* = b_2^*$*. Let* b^* *denote the equilibrium levels of borrowing in periods 1 and 2. Then, the optimal allocation satisfies*

$$u'\left(b^*\left[1 - F\left(2\frac{b^*}{\phi}\right)\right]\right)\left[1 - F\left(2\frac{b^*}{\phi}\right) - 2\frac{b^*}{\phi}f\left(2\frac{b^*}{\phi}\right)\right] = \beta\mathbb{E}\left[u'\left(c_3^*\right)\left[1 - \hat{d}(b^*, b^*, y_3)\right]\right]. \quad (10)$$

Assuming linear utility, equation (10) holds if and only if

$$1 - 2\frac{b^*}{\phi}\frac{f\left(2\frac{b^*}{\phi}\right)}{1 - F\left(2\frac{b^*}{\phi}\right)} = \beta. \quad (11)$$

Assumption 1 guarantees that there is a unique level of $2\frac{b^*}{\phi}$ *that solves equation (11). Let* η *denote this level. Then, for any economy with cost of defaulting* ϕ, $b^* = \frac{\eta\phi}{2}$*, and the optimal debt-brake threshold is given by* $\bar{b}^* = \eta\phi$*. For any* ϕ*, welfare gains obtained with the debt-brake threshold* $\bar{b}^* = \eta\phi$ *can also be obtained with the spread brake threshold* $\underline{q}^* = 1 - F(\eta)$ *(Proposition 3).*

Since $\underline{q}^* = 1 - F(\eta)$ *is not a function of* ϕ*, for any set of economies with different levels of* ϕ*, the optimal common spread-brake threshold is* $\underline{Q}^* = 1 - F(\eta)$*. And in every economy of the set,* $\underline{Q}^*$ *implements the borrowing sequence that maximizes the government's expected utility in period 1. In contrast, any common debt-brake threshold* $\bar{B}$ *can implement the borrowing sequence that maximizes the government's expected utility in period 1 in at most one economy of the set (because the optimal debt threshold for each economy in the set* $\bar{b}^* = \eta\phi$ *is an increasing function of* ϕ*). Therefore, the optimal common spread-brake threshold* $\underline{Q}^*$ *generates larger welfare gains than any common debt-brake threshold* $\bar{B}$*.*

Proposition 4 is intuitive. First note that the optimal debt-brake threshold $\bar{b}^* = \eta\phi$ in an increasing function of the cost of defaulting ϕ. Intuitively, economies with less debt intolerance (i.e., with a higher cost of defaulting that allows them to pay a lower interest rate when they borrow) should be allowed to borrow more. A common debt-brake threshold $\bar{B}$ cannot achieve this. In contrast, a common spread-brake threshold can: economies with less debt intolerance can borrow more while paying a spread bellow the common limit imposed by the spread brake.

This intuition holds beyond the assumptions in Proposition 4. These assumptions allow us to obtain closed-form solutions for the optimal fiscal rule thresholds and allow the optimal common spread brake to deliver exactly the welfare gains one would obtained with individual fiscal rules customized for each economy. We next present a numerical example in which these assumptions are violated. Nevertheless, the optimal common spread brake still outperforms the optimal common debt brake.

2.3.2 Optimal common fiscal rule and debt intolerance: numerical example

Assume $u(c) = -c^{-1}$, $\beta = 1$, $log(y_3) \sim N(0, 0.1)$, and $\delta = 0$. Optimal common fiscal rules are obtained assuming a uniform distribution for the cost of defaulting: $\phi \sim h(\phi) = U[0.1, 0.9]$. At the end of period 2, these economies display debt levels between 25 and 169 percent of average period 3 income, and spreads between 1 and 12 percent. Economies suffering more debt intolerance (i.e., with a lower ϕ) pay higher spreads for lower debt levels (even though within each economy higher debt levels imply higher spreads). We search for either the common debt-brake threshold $\bar{B}$ or the common spread-brake threshold $\underline{Q}$ that maximizes average welfare for this set of economies.

Figure 2 shows that the optimal common spread brake outperforms the optimal common debt brake. In economies with higher debt intolerance (ϕ lower than 0.4), the welfare gain obtained with the optimal common spread brake tracks very closely the one obtained with the optimal rule customized for each economy.[10] However, the optimal common spread-brake threshold does not bind in economies that have a higher cost of defaulting ϕ and thus pay a lower spread (welfare gains are zero in Figure 2). This occurs because a binding spread threshold in low debt intolerance economies would impose very tight borrowing constraints in high debt intolerance economies. And gains from restricting borrowing in low debt intolerance economies (that have a lesser debt dilution problem) are outweighed by the cost a lower common spread threshold would impose in economies with more debt intolerance (that are more borrowing constrained).

[10]Throughout the paper, we measure welfare gains as the constant proportional change in consumption (of the private good) that would leave domestic consumers indifferent between staying in the benchmark economy (without a fiscal rule) and moving to an economy with a fiscal rule (we introduce consumption of public goods in the next section).

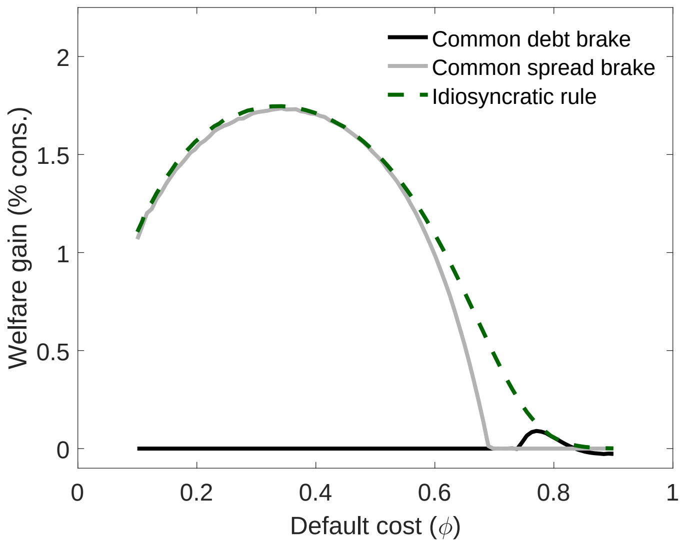

Figure 2: Welfare gains from imposing fiscal rules.

As the optimal common spread brake, the optimal common debt brake avoids excessive borrowing constraints for low debt intolerance economies (recall that the government does not receive income in the first two periods and thus is eager to borrow). However, in contrast with the optimal common spread brake, in order to avoid an excessive constraint in low debt intolerance economies, the optimal common debt brake has to avoid a binding constraint in economies with higher debt intolerance (that choose lower debt levels without a fiscal rule). Thus, the optimal common debt brake fails to generate significant welfare gains.

2.3.3 Optimal common fiscal rule and government patience

This subsection focuses on set of economies that differ in the value of the discount factor β. This is a stylized way of representing heterogeneity in optimal borrowing needs that may be due, for example, to heterogeneity in investment opportunities or expected income growth.

For a more impatient government (or a government in an economy with better investment opportunities and higher expected growth), it is optimal to pay a higher spread. For instance, it is clear from equation (11) that for a lower β, the optimal debt level is higher, and then the optimal spread is higher. We next focus on economies for which the optimal spread may be very different. If governments with better investment opportunities and higher expected income growth should be allowed to pay a higher spread, would a common debt brake outperform a common spread brake? The next proposition indicates that it would not.[11]

Proposition 5 *For any set of economies that differ only in the value of β, the optimal common debt-brake threshold $\bar{B}^*$ generates the same welfare gain than the optimal common spread-brake threshold $\underline{Q}^*$ in every economy in the set.*

Proof: *Since $f(y_3) > 0$ for all y_3, q_2 is a strictly decreasing function of $b_1(1-\delta)+b_2$. Therefore, for any optimal common debt-brake threshold $\bar{B}^*$ we can uniquely define the common spread-brake threshold $\underline{Q}^* = 1 - F\left(\frac{\bar{B}^*}{\phi}\right)$. Since q_2 is not a function of β, $\bar{B}^*$ and $\underline{Q}^*$ impose the same constraint and thus generate the same welfare gain in every economy in the set.*

The key assumption for the result in Proposition 5 is that economies are different in their willingness to borrow but face the same debt intolerance (i.e., the same mapping from debt to spreads). Therefore, for any debt limit there is a spread limit that imposes the same constraint in every economy in the set. This is in sharp contrast with the results in the previous subsections, where we assume that each economy face a different level of debt intolerance. As discussed before, there is ample evidence of variation in debt intolerance both across countries and over time.

We next study a quantitative model where the spread is also a function of shocks outside the control of the government, and parameter values can be calibrated to match salient features of the data. We show that the results highlighted in this section are robust: (i) for set of economies with different levels of debt intolerance, a common spread brake outperforms a common debt brake but (ii) for set of economies that differ mainly in their willingness to borrow, both fiscal rules generate similar welfare gains.

[11]Note that Proposition 4 establishes that a common spread brake outperforms a common debt brake for a set of economies for which it optimal to pay the same spread (reflected in the optimal common spread brake threshold $\underline{Q}^* = 1 - F(\eta)$).

3 The quantitative model

We first present the benchmark model without fiscal rules, and then discuss how we model fiscal rules.

3.1 The no-rule benchmark

The domestic economy lives for an infinite number of periods and is populated by continua of firms and households. Aggregate output $y = e^z l$ is determined by a TFP shock z and labor hours l. The logarithm of domestic TFP follows an AR(1) process:

$$z_t = (1-\rho)\,\mu_z + \rho z_{t-1} + \varepsilon_t, \tag{12}$$

with $\varepsilon_t \sim N\left(0, \sigma_\epsilon^2\right)$.

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

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta^{j-t} u\left(c_j, g_j, 1-l_j\right),$$

where $\mathbb{E}$ denotes the expectation operator, β the subjective discount factor, u the household's utility function, c private consumption, and g the public good provided by the government.

In each period, the representative household makes labor-leisure decisions by solving

$$\begin{aligned} &\max_{l} u\left(c, g, 1-l\right) \\ &\text{subject to} \\ &c = e^z(1-\tau)l, \end{aligned} \tag{13}$$

where τ denotes the labor tax rate, and thus $e^z(1-\tau)$ denotes the after-tax wage. The government finances g with the distortionary labor tax τ and with issuances of defaultable debt. Previous versions of this paper present equivalent results in stochastic-exchange economies without public goods.

As in Hatchondo and Martinez (2009), we assume that a bond issued in period t promises an infinite stream of coupons, with coupon payments decreasing 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 $s \geq 2$. The value of δ is calibrated to match the observed duration of sovereign debt in the data. In order to avoid increasing the computation cost, we do not allow the government to choose the maturity of sovereign debt. Hatchondo et al. (forthcoming) show that mitigating the dilution problem would allow the government to increase the average duration of sovereign debt and thus lessen rollover risk. This would constitute an additional benefit from introducing fiscal rules that we do not study here.

As in previous studies, when the government defaults, it does so on all current and future debt obligations. A defaulting sovereign is excluded from debt markets and faces a TFP loss of $\phi(z)$ in every exclusion period.

Following Hatchondo et al. (forthcoming), we capture in a simple fashion the positive recovery rate of debt in default observed in the data. Starting from the first period after the government defaults, the government is presented with the opportunity to end the default with time-invariant probability ξ. In order to end the default, the government needs to exchange the bonds that are in default with bonds that promise to pay $\alpha < 1$ times the payments promised by the exchanged bonds. The government may choose to not restructure the debt and continue in default, in which case its debt level will still be α times the debt level before the restructuring opportunity (thus, the government can obtain a lower recovery rate at the expense of a longer default period). During default, the government's payment obligations grow at the interest rate r.

In a model with long-term debt, a positive recovery rate may give the government incentives to issue large amounts of debt before defaulting, which would allow for a large increase in consumption (Hatchondo et al., 2014). Following Hatchondo et al. (forthcoming), in order to avoid this problem, we assume that the government cannot issue bonds at a price lower than $\underline{q}$ (the secondary market price of government debt can still be lower than $\underline{q}$). We choose a value of $\underline{q}$ that eliminates consumption booms before defaults and is never binding in the simulations.

Bonds are priced in a competitive market inhabited by a large number of foreign investors. Thus, bond prices are pinned down by the foreign investors' zero-expected-profit condition. Foreign investors are risk-neutral and discount future payoffs at the rate r.

The timing within each period is as follows. At the beginning of each period, the TFP shock is realized. A government not in default chooses whether to default, and a government in default chooses whether to end the default if it is presented with the opportunity to do so. At the end of each period the government chooses the level of public expenditures g, the labor tax rate, and when it is not in default, the number of bonds it wants to issue (or buy back).

We focus on Markov Perfect Equilibrium. That is, we assume that in each period, the government's equilibrium strategies depend only on payoff-relevant state variables.

3.2 Recursive formulation of the no-rule benchmark

Let b denote the number of outstanding coupon claims at the beginning of the current period. Let V denote the value function of a government that is not currently in default. This function satisfies the following functional equation:

$$V(b,z) = \max\left\{V^R(b,z), V^D(b,z)\right\}, \tag{14}$$

where V^R and V^D denote, respectively, the continuation value when the government repays its debt obligations, and when it declares a default.

If the government repays its current debt obligations, it has to decide how many bonds to issue in the current period, the tax rate (τ), and the level of government expenditures (g). The value function under repayment satisfies the following functional equation:

$$V^R(b,z) = \max_{b'\geq 0, c\geq 0, g\geq 0, \tau\geq 0}\left\{u\left(c,g,1-l\right) + \beta\mathbb{E}_{z'|z}V(b',z')\right\}, \tag{15}$$

subject to

$$g = \tau e^z l - b + q(b',z)\left[b' - (1-\delta)b\right],$$

$$c = (1-\tau)e^z l,$$

$$l = \hat{l}\left(z,\tau,c,g\right)$$

$$q\left(b',z\right) \geq \underline{q} \text{ if } b' > b, \tag{16}$$

where $b' - (1-\delta)b$ denotes current debt issuances, q denotes the price of a bond at the end of a period, and $\hat{l}$ denotes the equilibrium labor hours supplied by households ($\hat{l}$ solves problem 13).

The government cannot issue debt if it remains in default but continues to decide the tax rate and the level of government expenditures. The value function when the government is in default satisfies the following functional equation:

$$V^D(b,z) = \max_{c\geq 0, g\geq 0, \tau\geq 0} u\,(c,g,1-l) + \beta \mathbb{E}_{z'|z}\left[(1-\xi)V^D(b(1+r),z') + \xi V(\alpha b(1+r),z')\right], \quad (17)$$

subject to

$$g = \tau\left[e^z - \phi(z)\right] l,$$

$$c = (1-\tau)\left[e^z - \phi(z)\right] l,$$

$$l = \hat{l}\left(log(e^z - \phi(z)), \tau, c, g\right).$$

The assumption that bond holders price bonds in competitive markets implies that

$$q(b',z)(1+r) = \mathbb{E}_{z'|z}\left[\hat{d}\left(b',z'\right)q^D(b',z') + \left[1-\hat{d}\left(b',z'\right)\right]\left[1+(1-\delta)\,q(\hat{b}(b',z'),z')\right]\right], \quad (18)$$

where $\hat{d}$ denotes the government's default strategy and takes a value of 1 when the government defaults and a value of 0 when it pays, q^D denotes the price of a bond in default, and $\hat{b}$ denotes the debt policy rule. The price of a bond in default is given by

$$\begin{aligned} q^D(b',z)(1+r) &= \mathbb{E}_{z'|z}\left[(1-\xi)(1+r)q^D(b'(1+r),z')\right. \\ &\quad \left. +\xi\alpha\left[d'q^D\left(\alpha b',z'\right) + \left(1-d'\right)\left[1+(1-\delta)\,q(b'',z')\right]\right]\right], \end{aligned}$$

where $d' = \hat{d}\,(\alpha b', z')$, and $b'' = \hat{b}(\alpha b', z')$.

3.3 Equilibrium definition for the no-rule benchmark

A Markov Perfect Equilibrium is characterized by

1. rules for default $\hat{d}$, borrowing $\hat{b}$, government expenditure $\left\{\hat{g}^R, \hat{g}^D\right\}$, taxes $\left\{\hat{\tau}^R, \hat{\tau}^D\right\}$, and consumption $\left\{\hat{c}^R, \hat{c}^D\right\}$,
2. a bond price function q,

such that:

(a) given a bond price function q; the policy functions $\hat{d}$, $\hat{b}$, $\hat{g}^R$, $\hat{g}^D$, $\hat{\tau}^R$, $\hat{\tau}^D$, $\hat{c}^R$, $\hat{c}^D$ solve the Bellman equations (14), (15), and (17).

(b) given $\hat{d}$ and $\hat{b}$, the bond price function q satisfies equation (18).

3.4 Fiscal rules

We study two rules. A debt-brake rule imposes a ceiling on the fiscal budget balance to prevent the sovereign debt level to go beyond a threshold $\bar{b}$. Thus, a debt brake imposes an additional constraint $b' \leq \max\{\bar{b}, (1-\delta)b\}$ on functional equation (15).[12]

A spread-brake rule imposes a ceiling on the fiscal budget balance that prevents the government from increasing its debt level to push the sovereign spread beyond a threshold. Limiting the spread is equivalent to imposing a minimum sovereign bond price. Thus, the spread brake simply entails increasing the minimum price at which the government can sell bonds while increasing its debt level ($\underline{q}$) in equation (16).Note that equation (16) implies that the government can always issue up to δb bonds at a price lower than $\underline{q}$. This is, the government can always roll over debt payments that are due this period. The spread brake only prevents that the government increases its debt level when the implied spread is higher than the brake limit. Furthermore, even when the government does not issue debt priced lower than $\underline{q}$, the price of debt issued in previous periods may be lower than $\underline{q}$. Thus, one can observe spreads higher than the spread-brake threshold.

4 Benchmark calibration

We first present a benchmark calibration. Later, we study sets of alternative parameterizations that differ from the benchmark calibration only in the value of one parameter, implying differences in debt intolerance or the government's eagerness to borrow.

[12]Note that the constraint $b' \leq \max\{\bar{b}, (1-\delta)b\}$ never forces the government to buy back debt. This is important to avoid negative consumption when we evaluate the model for initial debt levels higher than the debt-brake threshold $\bar{b}$ (which are outside the ergodic set for debt-brake economies).

Table 1 presents the benchmark calibration. A period in the model refers to a quarter. We estimated equation (12) using quarterly real GDP data from Spain for the period from the first quarter of 1960 to the first quarter of 2013. As in Cuadra et al. (2010), we assumed that preferences are described by the following function:

$$u(c,g,l) = \pi \frac{g^{1-\gamma_g}}{1-\gamma_g} + (1-\pi)\frac{\left[c - \psi l^{1+\omega}/(1+\omega)\right]^{1-\gamma}}{1-\gamma}.$$

We assumed that domestic households have a coefficient of relative risk aversion on private consumption (γ) of 2. The inverse of the labor elasticity (ω) and the weight of labor hours on the utility (ψ) are taken from Neumeyer and Perri (2005), who study business cycles in small open economies. As explained below, the weight of public consumption in the utility (π) and the risk aversion for public consumption (γ_g) are calibrated to fit targets from the data.

We assume an annual risk-free rate of 4 percent, which is standard in the literature. The recovery rate of debt in default (α) is assumed to take a value of 0.35. This is the average recovery rate reported by Cruces and Trebesch (2013) for debt restructurings with a reduction in the face value (we find that in the simulations, the government chooses to exit a default every time it has the opportunity of doing so). The probability with which a government can exit a default (ξ) delivers an average exclusion from debt markets of three years after a default. This is the estimate obtained by Dias and Richmond (2007) for the median duration of exclusion from debt markets using their partial access definition of re-entry.

We assume that the minimum issuance price for long-term debt ($\underline{q}$) equals 30 percent of the price of a default-free long-term bond. This constraint is not binding in the simulations. The yield to maturity implied by the assumed value of $\underline{q}$ is higher than the maximum yield to maturity at which any European government issued debt since 2008 (see Trebesch and Wright, 2013).[13]

As in Arellano (2008) and Chatterjee and Eyigungor (2012), we assume that it is proportionally more costly to default in good times. They show that this property is important in accounting for the dynamics of the sovereign debt interest rate spread. Mendoza and Yue (2012) show that this property of the cost of defaulting arises endogenously in a setup in which defaults affect the ability of local firms to acquire a foreign intermediate input good. Thus, we assume

[13]We thank Christoph Trebesch and Mark Wright for sharing their data with us.

Domestic income autocorrelation coefficient	ρ	0.97	Spain 1960Q1-2013Q1
Standard deviation of domestic innovations	σ_ϵ	1.04%	Spain 1960Q1-2013Q1
Mean TFP	μ_y	$(-1/2)\sigma_\epsilon^2$	Mean TFP = 1
Risk aversion of private consumption	γ	2	Prior literature
Inverse of labor elasticity	ω	0.6	Neumeyer and Perri (2005)
Weight of labor hours	ψ	$2.48/(1+\omega)$	Neumeyer and Perri (2005)
Risk-free rate	r	0.01	Prior literature
Recovery rate of debt in default	α	0.35	Cruces and Trebesch (2013)
Duration of defaults	ξ	0.083	Dias and Richmond (2007)
Minimum issuance price without fiscal rule	$\underline{q}$	$0.3\bar{q}$	Never binding in simulations
Duration of long-term bond	δ	0.0275	Calibrated to fit targets
Discount factor	β	0.97	Calibrated to fit targets
Income loss while in default	λ_0	-0.731	Calibrated to fit targets
Income loss while in default	λ_1	0.9	Calibrated to fit targets
Risk aversion for public consumption	γ_g	3	Calibrated to fit targets
Weight of public consumption	π	0.182	Calibrated to fit targets

Table 1: Parameter values. The price of a default-free long-term bond is denoted by $\bar{q}$.

that $\phi(z)/exp(z)$ is increasing in z. In particular, we assume a quadratic TFP loss function during a default episode $\phi(z) = max\left\{\lambda_0 e^z + \lambda_1 e^{2z}, 0\right\}$.

There are six remaining parameter values: the rate of decay of coupon obligations $(1-\delta)$, the two parameters that define the TFP cost of defaulting (λ_0, λ_1), the discount factor (β), the weight of public consumption in the utility (π), and the risk aversion for public consumption (γ_g). These parameter values are calibrated to match six moments in the data: (i) the average duration of government debt, (ii) the level of government debt, (iii) the average interest rate spread, (iv) the volatility of private consumption relative to the volatility of income, (v) the ratio of government consumption to private consumption (g/c), and (vi) the volatility of government consumption relative to the volatility of income. For the targets, we use data from Spain from 2008 to 2013. We chose this period because the interest rate spread paid by the Spanish government was around zero between 1999 and 2007, and before the introduction of the euro the Spanish government issued debts denominated in local currency. As Hatchondo et al. (2010), we solve the model numerically using value function iteration and interpolation.[14]

Our findings are robust to changes in the calibration. In previous working paper versions of this study, we presented variations of the model (e.g., endowment economies and zero recovery rates after default) with the baseline calibration targeting data from Argentina before the 2001 default and thus featuring much lower debt levels and much higher spreads. We find essentially the same results on the advantages of a common spread brake over a common debt brake.

5 Simulations without a fiscal rule

Table 2 shows that the model without a fiscal rule approximates moments in the data well. Since there has not been a sovereign default in Spain in recent years, we report results for simulated sample paths without defaults. We report the mean of the value of each moment in 1,000 simulation samples. We take the last 74 periods (quarters) of samples in which no default occurs in the last 100 periods.

Figure 3 shows that it is optimal for the government to choose a pro-cyclical fiscal policy. That is, when aggregate output is lower, the tax rate tends to be higher, and the level of public good provision tends to be lower. When income is low, borrowing is more costly because it increases the probability of default (and future default decisions are not optimal from an ex-ante perspective). Thus, the government borrows less, increases the tax rate, and lowers expenditures. This is consistent with data from Spain (including fiscal adjustment during the current crisis) and other small open economies. For instance, Végh and Vuletin (2011) finds that the three

[14]We use linear interpolation for endowment levels and spline interpolation for asset positions. The algorithm finds two value functions, V^R and V^D, and the bond price q. We solve for the equilibrium of the finite-horizon version of the 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-economic equilibrium functions.

	Data	Benchmark
Mean debt-to-income ratio (in %)	61.8	61.5
Debt duration (years)	6.0	6.0
Annual spread (in %)	2.0	2.0
Mean g/c (in %)	36.5	36.5
$\sigma(g)/\sigma(y)$	0.9	0.9
$\sigma(c)/\sigma(y)$	1.1	1.1

Table 2: Simulations without a fiscal rule. The standard deviation of a variable x is denoted by $\sigma(x)$. The second column is computed using data from Spain. The logarithm of private consumption (c) and income (y) were de-trended using the Hodrick-Prescott filter, with a smoothing parameter of 1600. We report deviations from the trend. The debt level in the simulations is calculated as the present value of future payment obligations discounted at the average risk-free rate, i.e., $b(\delta + r)^{-1}$. We report the annualized spread.

industrial countries in their sample with the most pro-cyclical fiscal policies are Spain, Portugal, and Greece, all countries facing significant sovereign risk.

6 Idiosyncratic fiscal rules

In this section we discuss the fiscal rules that maximize welfare in a no-rule economy with the benchmark parameterization, when there is no initial debt and TFP is at its unconditional mean. We also discuss commitment to the optimal spread-brake rule.

6.1 Optimal idiosyncratic fiscal rules

For the benchmark economy, the optimal debt-brake threshold is 52.5 percent of the mean annual output. The optimal spread-brake threshold is 0.45 percent. Table 3 shows that the preferred debt and spread brake reduce the default frequency and, consequently, the sovereign spread.

As discussed in Section 2, the government benefits from implementing a fiscal rule because the rule mitigates the debt dilution problem. Figure 4 illustrates how a fiscal rule creates new borrowing opportunities. On the one hand, the fiscal rule forces the government to choose lower

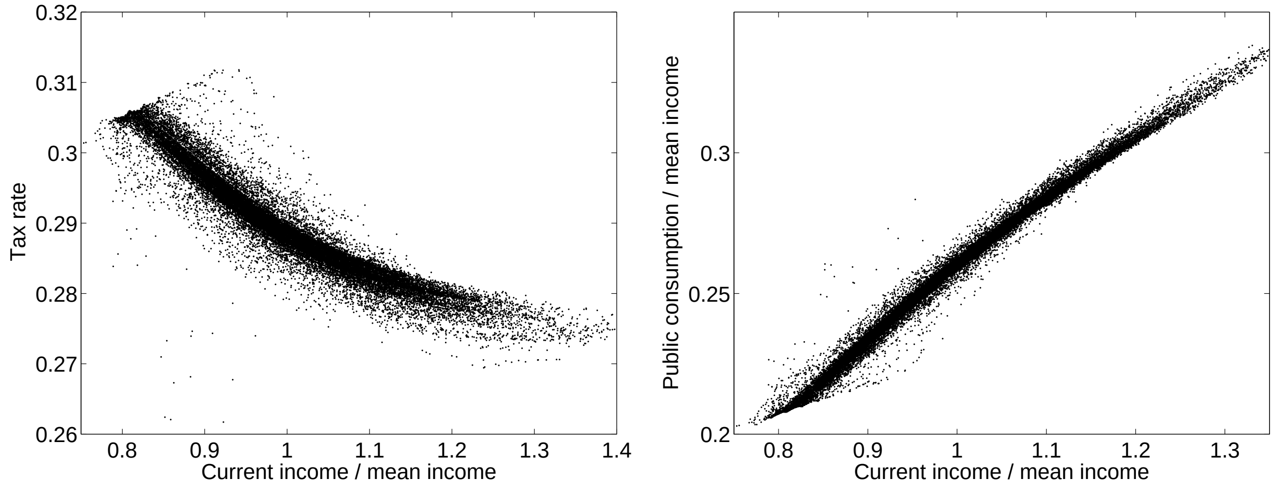

Figure 3: Procyclical fiscal policy.

debt levels. On the other hand, with the fiscal rule, for any chosen debt level, the government pays a lower interest rate (because lenders anticipate future governments will choose a lower debt level). Overall, a lower interest rate may allow the government to obtain more resources from borrowing even though it promises to pay less (right panel of Figure 4).

Figure 5 illustrates the benefits of anchoring expectations with a fiscal rule. The figure presents spread, debt, and consumption in one of the 1,000 simulation samples of 74 periods used for Table 3. The figure shows that the benchmark simulations without a fiscal rule feature very large and rapid increases in sovereign spread. In contrast, with the same shocks but with the optimal spread brake, the spread increases much less. Furthermore, with the spread brake, the spread returns to the pre-crisis level as soon as TFP recovers. In contrast, without a fiscal rule, the spread remains relatively high after TFP recovers. This is the case because with the spread brake, debt starts declining when TFP stabilizes but without the brake, debt continues to increase for 10 more quarters, an additional 10 percent of trend annual aggregate income. Thus without the rule, even after TFP recovers, the debt level continues to be high, keeping the economy in a weak position to withstand negative shocks. Figure 5 also shows that the smaller initial impact of negative shocks and the faster recovery of debt and spread levels with the brake are not the result of sacrifices of consumption triggered by the brake. By anchoring expectations

	Without rule	Debt brake (52.5%)	Spread brake (0.45%)
Mean debt-to-income ratio	61.5	54.9	59.4
Annual spread (in %)	2.0	0.5	1.0
Mean g/c (in %)	36.5	37.1	36.9
$\sigma(g)/\sigma(y)$	0.9	0.9	1.0
$\sigma(c)/\sigma(y)$	1.1	1.1	1.1
Defaults per 100 years	2.9	0.8	1.1
Welfare gain (in %)		0.5	0.4

Table 3: Simulations with fiscal rules. We measure welfare gains as the constant proportional change in consumption of the private good that would leave domestic consumers indifferent between staying in the benchmark economy (without a fiscal rule) and moving to an economy with a fiscal rule.

about future fiscal policy, the rule contains the initial spread increase, which in turn contains the government's interest bill, allowing for a faster deleveraging without any additional sacrifice of consumption.

Table 3 also shows that imposing a spread brake produces welfare gains comparable to those obtained with a debt brake. For a given economy (i.e., for a given set of parameter values), the difference between the limit to overborrowing imposed by a debt brake and the one imposed by a spread brake is that the latter implies a state-contingent limit on the debt level. Spreads are higher during economic downturns (when TFP and, thus, the cost of defaulting are lower). Consequently, a spread brake imposes a tighter constraint on debt increases during economic downturns. Section 10 shows that the government is worse off by allowing debt limits to be tighter during downturns, which is consistent with the lower welfare gains obtained with the spread brake in Table 3.

We do not want to focus on the difference between debt and spread limits due to the state-contingency of spreads because this difference could be corrected by imposing limits that change over the business cycle, as many countries have done (Budina et al., 2012; IMF, 2009; Schaechter et al., 2012). For instance, Germany's debt brake imposes fiscal adjustments only during economic expansions. Similarly, a spread brake could impose a limit on the fiscal balance only during

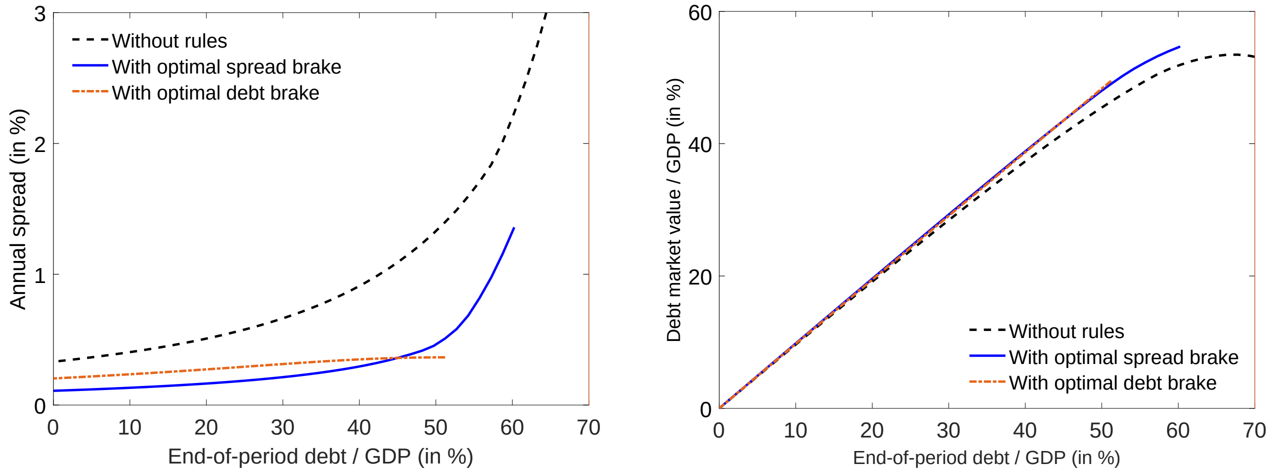

Figure 4: Borrowing opportunities. The left panel presents the annualized spread asked by lenders for different levels of debt. The right panel presents the market value of the debt stock (which represents the resources a government without debt could obtain from borrowing) for different levels of debt. The figure assumes the average TFP shock.

economic expansions. Instead of focusing on the difference between a debt brake and a spread brake due to state-contingency, this paper emphasizes the advantages of a spread brake as a common fiscal rule for several economies (Section 7).

6.2 Commitment to the optimal spread brake

Commitment to the optimal spread brake is not an issue in our framework. For all states of the economy, the expected utility of the representative household is higher in the economy with the optimal spread brake than in the no-rule benchmark. Thus, if we augment the model to allow a government to abandon the rule and go back to the no-rule benchmark, the government would never choose to do so. Similarly, if we give to a government in the no-rule benchmark the option to adopt the optimal spread brake, the government would adopt it in any state of the economy.

Assuming governments can only commit to simple rules mimics what countries are trying to do: looking for commitment to simple fiscal rules because they cannot commit to detailed future fiscal choices. Countries continue to strengthen their commitment to fiscal rules by introducing independent fiscal councils that provide public assessments of fiscal plans and performance, and evaluation or provision of macroeconomic and budgetary forecasts (right panel of Figure 1). In

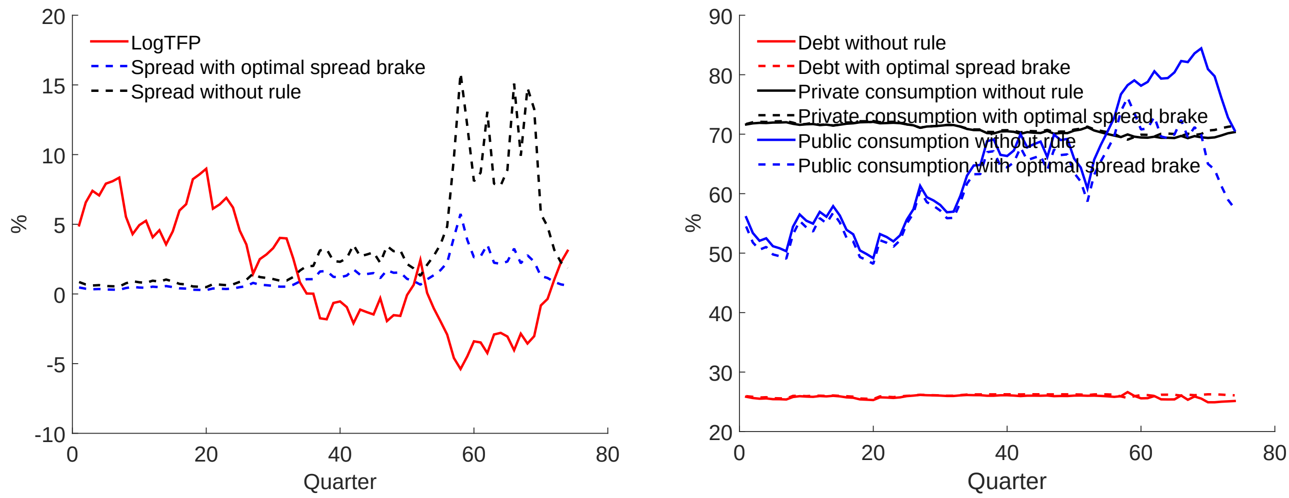

Figure 5: Simulations with and without a fiscal rule. The level of debt (consumption) is expressed as a percentage of current annual (quarterly) aggregate income.

addition, an increasing number of countries is implementing fiscal responsibility laws that set out procedural and transparency requirements. Fiscal rules are also being complemented with automatic sanctioning and enforcement procedures (see, for instance, Germany's and Switzerland's debt brakes, and other automatic correction mechanisms such as "sequestration" processes). Countries also continue to enhance the legal status of fiscal rules.[15] Moreover, supranational authorities can help enforce supranational rules. Hatchondo et al. (forthcoming) argue that sovereign debt covenants could help enforce fiscal rules. Moreover, fiscal rules based on market discipline (as advocated in this paper) could be less susceptible to accounting manipulations, facilitating commitment.

Empirical studies find that well-designed fiscal rules improve fiscal outcomes, indicating that governments can commit to these rules (Corbacho and Schwartz, 2007; Debrun and Kumar, 2007; Debrun et al., 2008; Deroose et al., 2006; EC, 2006; Kopits, 2004).[16] Heinemann et al.

[15]For example, Germany (in 2009) and Spain (in 2011) amended their constitutions to introduce fiscal rules. The super-majorities, referendums, or waiting periods typically required to amend a constitution limit the discretionary power of policymakers in office. Schaechter et al. (2012), Debrun and Kinda (2014), and Debrun et al. (2013) discuss country experiences with fiscal rules, transparency laws, and fiscal councils.

[16]Difficulties in identifying the effects of fiscal rules are well documented (Poterba, 1996; Heinemann et al., 2014). When comparing predictions in this paper with past experiences with fiscal rules, one should keep in mind that we are assuming certainty about the government's ability to commit to enforcing a rule, but such certainty has often been lacking in experiences to date.

(2014) and Iara and Wolff (2011) find that fiscal rules reduce the sovereign premium of European bonds. Feld et al. (2013), Lowry and Alt (2001), and Poterba and Rueben (1999) present similar evidence for subnational governments in the U.S. and Switzerland. These findings indicate that investors were moved by the commitment of governments to fiscal rules.

7 Common and robust fiscal rules

In this section we find the optimal common fiscal rule that maximize welfare for sets of heterogeneous economies. As in Section 2, we search for the optimal common fiscal rule threshold X^* that maximizes the expected utility of a set of economies indexed by the value of the parameter θ, with the density function for θ in this set denoted by $h(\theta)$. Thus, for each set of economies we change one parameter value and assume all other values are the ones in the benchmark calibration. In all cases we assume parameter values are uniformly distributed across the range of interest.

We study sets of economies that differ in either the level of debt intolerance or the government's eagerness to borrow. We change the level of debt intolerance in two ways: (i) we assume the duration of a defaulting government' exclusion from debt markets is between 1 and 5 years ($\xi \sim U[0.05, 0.25]$), or (ii) we assume the recovery rate for debt in default is between 10 and 60 percent ($\alpha \sim U[0.1, 0.6]$). Increasing the exclusion duration increases the cost of defaulting and thus allows a government to pay a lower interest rate for any debt level. This leads the government to choose higher debt levels. Increasing the recovery rate lowers the lenders' losses after a default, and thus allows the government to pay a lower interest rate for any debt level and also leads it to choose higher debt levels. We change the government's eagerness to borrow by assuming the discount factor is between 0.95 and 0.985 ($\beta \sim U[0.950, 0.985]$).

Overall, we study parameter values that are within the range of values commonly assumed in quantitative studies of sovereign default. Figure 6 shows that these parameter values also generate average levels of sovereign debt (between 30 and 90 percent) and spreads (between 0.5 and 5.8 percent) consistent with those observed across countries.

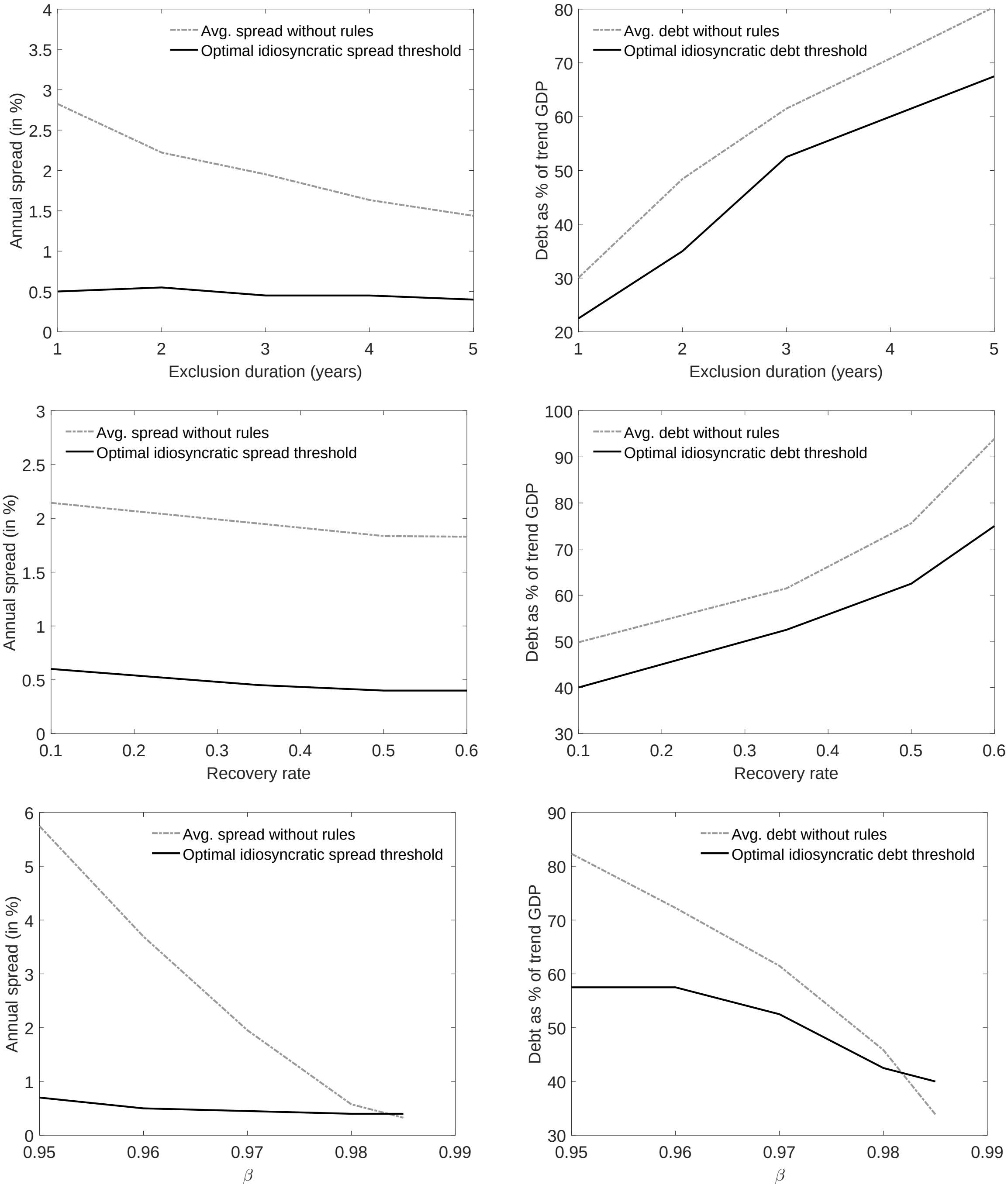

Figure 6: Average debt and spread levels and optimal idiosyncratic fiscal-rule thresholds in different economies. The exclusion duration is the average number of years a government is excluded from debt markets after defaulting.

Set of economies with different	Exclusion duration	Recovery rate	Discount factor
	Optimal common limit		
Debt-brake threshold (in %)	60.00	60.00	50.00
Spread-brake threshold (in %)	0.45	0.40	0.50
	Welfare gains with common debt brake		
Average (in %)	0.24	0.23	0.16
Maximum (in %)	0.55	0.48	0.41
Minimum (in %)	0.00	0.00	0.00
	Welfare gains with common spread brake		
Average (in %)	0.34	0.34	0.17
Maximum (in %)	0.36	0.45	0.45
Minimum (in %)	0.28	0.20	0.01

Table 4: Welfare gains from common fiscal rules.

7.1 Optimal common fiscal rules

Table 4 and Figure 7 show that for the three sets of economies we consider, the welfare gain is higher with a common spread brake than with a common debt brake. Furthermore, a common spread brake produces less dispersion in welfare gains across economies.

The poorer performance of a common debt brake follows the intuition presented in Section 2. In economies with more debt intolerance the common debt brake is rarely binding and thus does not have significant effects. In fact, for the economies with the most debt intolerance, the common debt brake fails to achieve welfare gains. In contrast, in economies with less debt intolerance the common debt brake may be too tight. This is apparent from the sharp decline in the welfare gain generated by the common debt brake for the economies with the least debt intolerance in the top panels of Figure 7. Thus, while the results in Section 6 illustrate the potential benefits from imposing a debt brake that can be tailored to a single economy with known characteristics, this section illustrates significant limitations of debt brakes as a common rule for a set of heterogeneous economies or as the fiscal rule for an economy for which uncertainty about

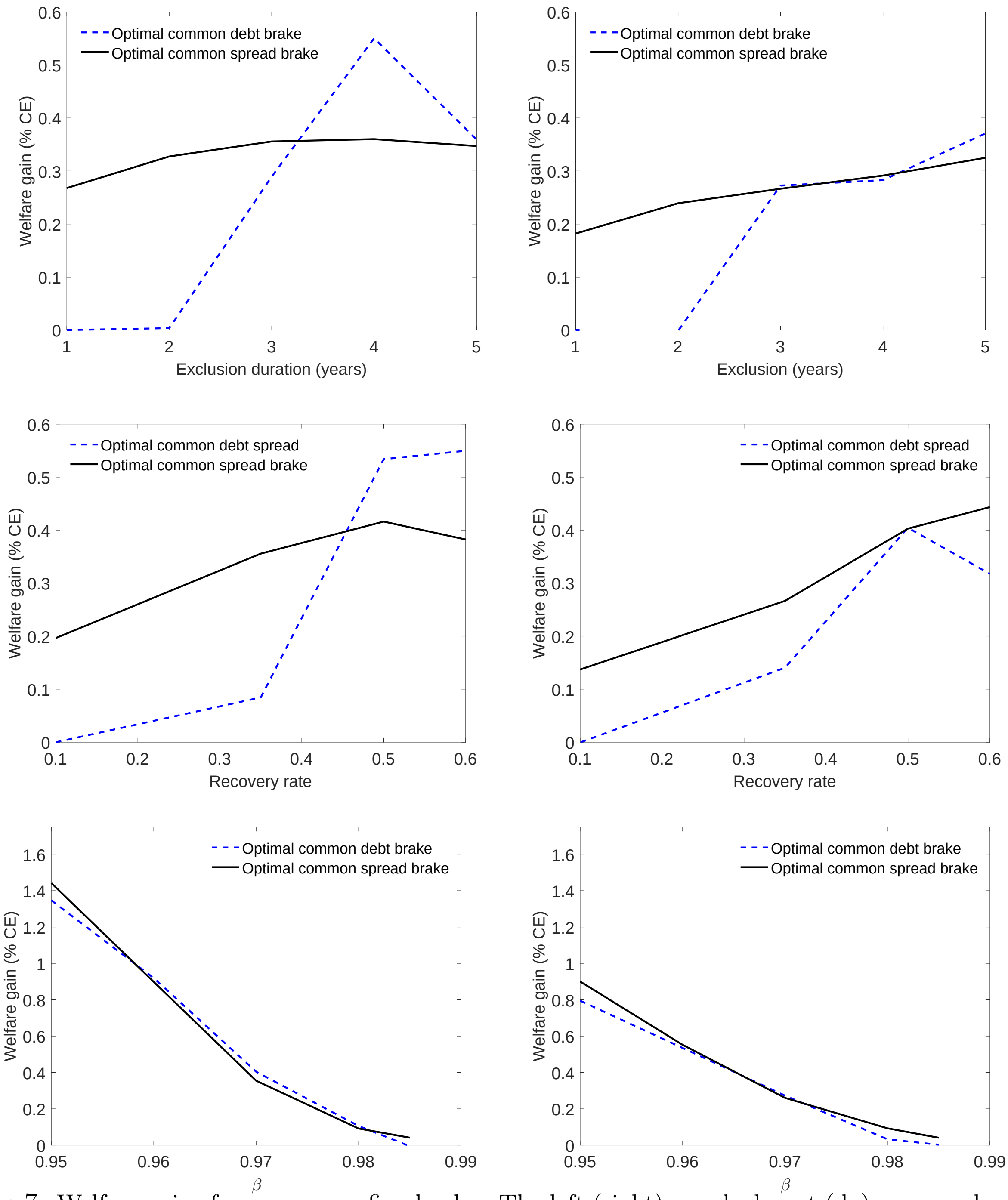

Figure 7: Welfare gains from common fiscal rules. The left (right) panels do not (do) assume shocks to the lenders' risk aversion. In the left (right) panels, the optimal common debt threshold is 52.5 (50.0) percent of the mean level of annual income, and the optimal common spread threshold is 0.45 (1.00) percent. Welfare gains are computed assuming an initial state without debt, the mean TFP shock and, in the right panels, the lower risk premium.

key characteristics remains unresolved. In contrast, since the spread incorporates information about the level of debt intolerance in each economy, a common spread brake can force lower debt levels for economies with more debt intolerance while allowing for higher debt levels in economies with less debt intolerance.

Table 4 and Figure 7 show that the difference between welfare gains obtained with a common debt or spread brake is smaller when governments differ in their eagerness to borrow. This is consistent with the result presented in Proposition 5. In contrast with Proposition 5, here welfare gains are not exactly the same with the optimal common debt and spread brakes because since the cost of defaulting is realized in part in the future, the government's discount factor affects the cost of defaulting and thus the level of debt intolerance (i.e., the mapping from debt to spread levels).

Figure 6 also illustrate how it may be easier to provide robust policy recommendations and common fiscal anchors using spreads rather than debt levels. The optimal idiosyncratic spread-brake thresholds for the economies we study in this section range from 0.4 to 0.7 percent (left panels of Figure 6) even though the average spread observed without a rule in these economies displays a significantly wider variation: from 0.5 to 5.8 percent. In contrast, Figure 6 shows that the optimal idiosyncratic debt-brake threshold ranges is between 20 percent and 80 percent, changing almost one to one with the average debt level observed without a fiscal rule (between 30 and 90 percent).

8 Political myopia

This section shows that assuming political myopia implies stricter fiscal rules and increases the gains to be had by introducing fiscal rules. It also shows that a common spread brake performs as well as a common debt brake in a set of economies that differ only in the degree of political myopia but display similar levels of debt intolerance. Political myopia (for instance, because of political polarization or political turnover) is typically mentioned as a justification for fiscal rules. Previous sections show that fiscal rules can be beneficial even in the absence of political myopia.

To gauge the role of shortsighted governments, suppose in every economy agents discount future utility flows with a factor $\beta^A = 0.99$. The degree of political myopia is then given by the difference between the agents' discount factor β^A and the discount factor used by the government when making decisions, β. We search for the optimal fiscal rule in a set of economies with $\beta \sim U[0.950, 0.985]$, that then display different degrees of political myopia. We assume fiscal rules are chosen maximizing welfare while discounting future utility flows with β^A. For instance, one may think that the political coalition needed to establish a fiscal rule in the constitution requires a majority that mitigates the effects of political polarization when future outcomes are discounted (for a discussion of the effects of polarization on fiscal dynamics, see Azzimonti, 2011).

As expected, assuming political myopia implies that optimal fiscal rules are stricter. Note that the set of economies studied in this section ($\beta \sim U[0.950, 0.985]$) is the same set we study in Section 7. The only difference is that in this section we assume that variations in the government's discount factor represent variations in political myopia, and we evaluate welfare using $\beta^A = 0.99$ for all the economies in the set (in contrast, in Section 7 we evaluate welfare in each economy using the discount factor of the government for that economy. We find that with political myopia, the optimal thresholds for the common debt and spread brakes are 33 and 0.2 percent, respectively. These thresholds are lower than the ones we found in Section 7 for the set of economies with different discount factors (50 and 0.5 percent, respectively; Table 4). The comparisson of the bottom panels of Figure 6 with Figure 11 shows that for each economy in the set, optimal idiosyncratic rule thresholds are lower with political myopia.

Figure 11 also shows that, as for the sets of economies studied in Section 7, there is little variation in the optimal idiosyncratic spread-brake threshold for economies with different political myopia (optimal thresholds range from 0 to 0.5 percent), even though the average spread observed without a rule in these economies displays a significantly wider variation (ranging from 0.5 to 5.8 percent). This is again indicative of the robustness of policy advise on spread-brake thresholds that would result from this framework.

Comparing Figure 9 and the bottom left panel of Figure 7 shows that, as expected, fiscal rules generate larger welfare gains when they also mitigate the effects of political myopia. In addition, Figure 9 shows that across economies with different degrees of political myopia, changes

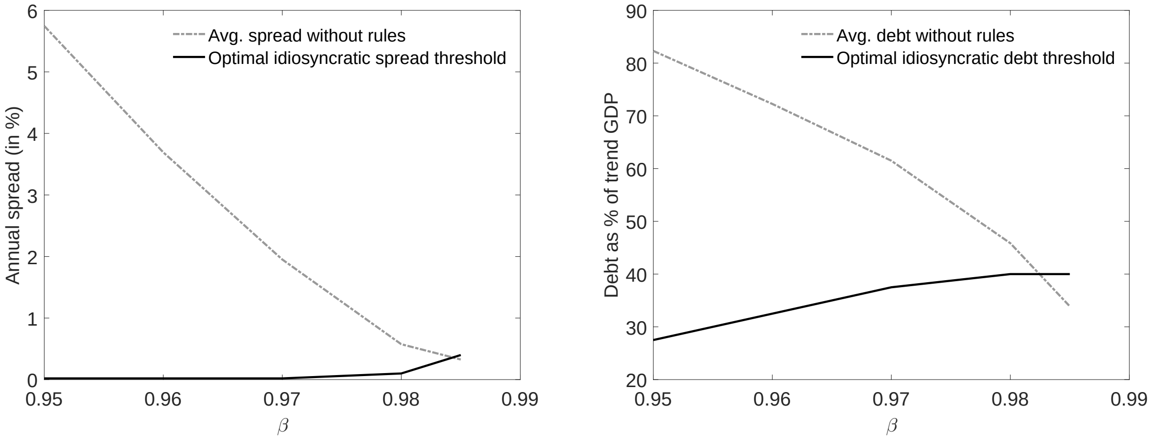

Figure 8: Average debt and spread levels and optimal idiosyncratic rule thresholds in economies with different degrees of political myopia.

in the welfare gain generated by a common fiscal rule are similar with either a common debt or spread brake.[17] This is consistent with the results presented in Sections 2 and 7 for sets of economies with different impatience: the common debt and spread brakes perform similarly in sets of economies that have similar levels of debt intolerance but differ in other characteristics that do not have a significant effect in the mapping from debt to spreads.

It should be emphasized, however, that countries with more severe political frictions often pay a higher spread for lower debt levels (Figure 10). This indicates that countries with more severe political frictions typically suffer a more severe problem of debt intolerance. In contrast, Figure 11 shows that model economies with more political myopia display much higher debt levels in the simulations. For a set of economies capturing the positive correlation between political myopia and debt intolerance, the advantage of a common spread brake discussed in the previous subsections would arise again.

[17]As in the benchmark, welafare gains in Figure 9 are slitghlty higher with the debt brake than with the spread brake because of differences between the two rules that could be corrected. Instead of focusing on these differences, we focus on changes in the welfare gain generated by a common rule across parameter values.

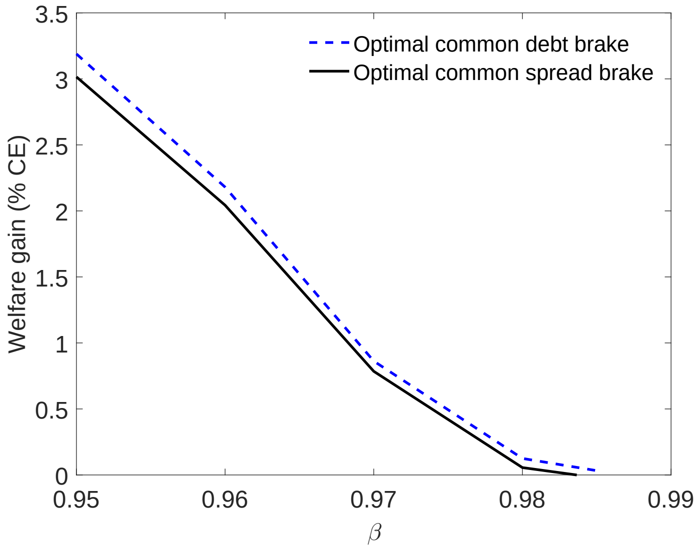

Figure 9: Welfare gains with government myopia.

9 Global factors and spread brakes

This section shows that the advantages of a common spread brake over a common debt brake are robust to the spread moving for reasons that are exogenous to domestic policies and even to domestic shocks. We introduce a shock to the risk aversion of lenders. Several studies find that investors' risk aversion is an important driver of global liquidity (Cerutti et al., 2014; Rey, 2013) and that a significant fraction of the sovereign spread volatility in the data is accounted for by the volatility of the risk premium (Borri and Verdelhan, 2009; Broner et al., 2007; Longstaff et al., 2011; González-Rozada and Levy Yeyati, 2008).

We assume the price of sovereign bonds satisfies a no-arbitrage condition with stochastic discount factor $M(\varepsilon', p) = exp(-r - p\varepsilon' + 0.5p^2\sigma_\epsilon^2)$, where $p \in \{p_L, p_H\}$ denotes the risk-aversion shock. In order to simplify the calibration, we assume that investors are risk neutral in some periods ($p_L = 0$) and risk averse in other periods ($p_H > 0$).[18] This model of the discount factor is a special case of the discrete-time version of the Vasicek one-factor model of the term structure (Vasicek, 1977; Backus et al., 1998) and has often been used in models of sovereign default (e.g.,

[18]The value of p can be interpreted as capturing the joint effect of lenders' risk aversion and the co-movement between shocks to lenders' wealth and the country's income. This formulation introduces a positive risk premium because bond payoffs are more valuable to lenders in states in which the government defaults.

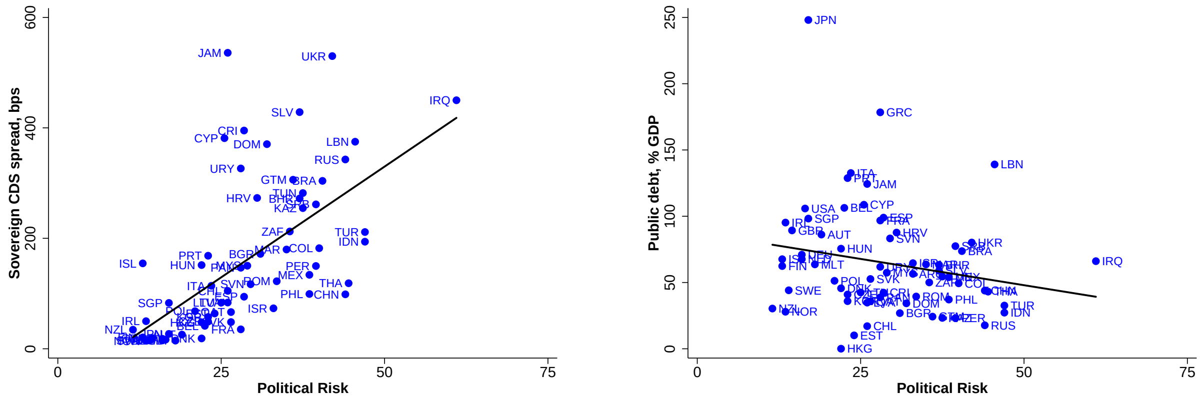

Figure 10: Political risk and debt intolerance. The Figure presents 2015 data (average levels for CDS spreads and political risk) for countries with CDS spreads (DataStream). Political risk equals 100 minus the Political Risk Rating of the International Country Risk Guide (that takes values from 0 to 100, with a higher value indicating more risk). Debt levels are from the April 2016 IMF World Economic Outlook.

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Arellano and Ramanarayanan, 2012). The risk-premium shock p follows a Markov process such that a high-risk-premium episode starts with probability $\pi_{LH} \in [0,1]$ and ends with probability $\pi_{HL} \in [0,1]$.

We assume there are three high-risk-premium episodes every twenty years ($\pi_{LH} = 0.0375$) and that each episode lasts on average for two years ($\pi_{HL} = 0.125$). Looking at the EMBI spread for all available countries not in default (according to Fitch) since 1994, one can identify three episodes of high average sovereign spreads (when spreads where higher than the sample mean plus one standard deviation) in the last twenty years: 1994-1995 (Tequila crisis), 1998-2001 (debt crises in emerging economies), and 2009 (Global Financial Crises). The average EMBI spread was 2.6 percent higher in those years than in normal years. We recalibrate the value of one of the parameters governing the TFP cost of defaulting (λ_0=-0.703) and assume $p_H = 70$ to obtain plausible levels for debt and the average increase in spreads during high-risk-aversion episodes (62 and 2 percent respectively; Table 5). All other parameter values are the ones used for the benchmark without risk premium.

Table 5 presents simulation results for the benchmark with time-varying lenders' risk aversion and the optimal debt and spread brakes for that benchmark. Not surprisingly, to be consistent

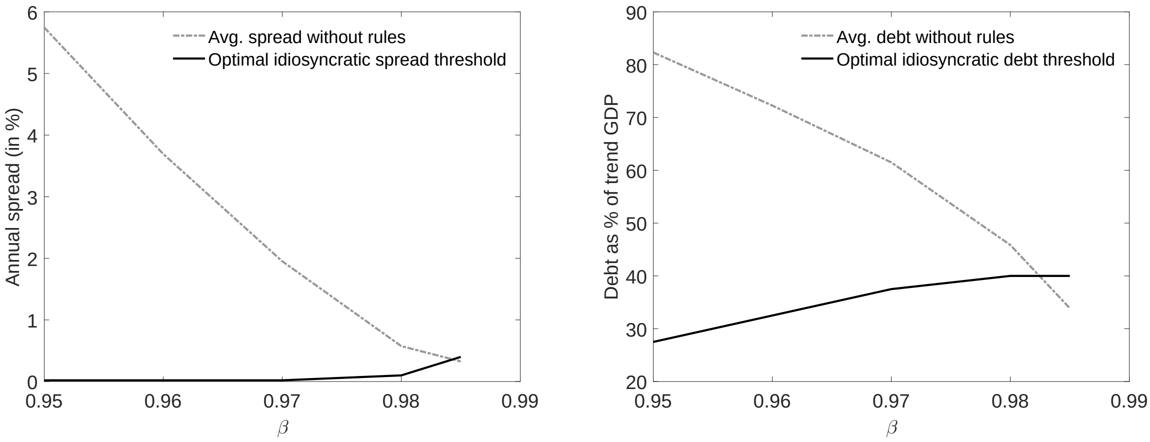

Figure 11: Average debt and spread levels and optimal rule thresholds in economies with different degrees of political myopia.

with plausible spread levels, a model with risk premium features a lower default frequency. Table 5 shows that the spread volatility due to shocks to the lenders' risk aversion does not create a comparative disadvantage for the spread brake: the optimal spread brake produces the same welfare gain than the debt brake. This is intuitive. An increase in the lenders' risk aversion increases the spread, making the spread limit binding, and thus preventing the government from increasing its level of indebtedness. But even without a spread brake it would not be optimal for the government to increase its debt level when doing so is particularly expensive because of the high risk premium demanded by lenders.[19] Therefore, the constraint imposed by the spread brake during episodes of high risk premium is not detrimental for welfare.

We next focus on the main question in the paper: would a common spread brake perform better than a common debt brake? In order to answer this question, we repeat the exercises presented in Section 7, for the same sets of parameter values, but now with shocks to the lenders' risk aversion (and λ_0=-0.703). Table 6 and the right panels of Figure 7 show that the main message of the paper is robust to introducing shocks to the lenders' risk aversion: compared with a common debt brake, a common spread brake generates a higher average welfare gain, and less disperse welfare gains across economies. Also consistent with our findings for risk-neutral

[19]The optimal policy for the government would be to increase debt in periods of low lenders' risk aversion in order to finance the accumulation of assets it can use in periods of high lenders' risk aversion (Bianchi et al., 2015).

	Without rule	Debt brake (50%)	Spread brake (1%)
Mean debt-to-income ratio (in %)	62.0	49.5	58.3
Annual spread (in %)	2.7	1.1	1.9
Average increase in spread during p_H	2.1	1.0	1.6
Mean g/c (in %)	36.6	37.3	36.9
$\sigma(g)/\sigma(y)$	1.0	0.9	1.0
$\sigma(c)/\sigma(y)$	1.1	1.1	1.1
Defaults per 100 years	0.9	0.1	0.3
Welfare gain (in %)		0.3	0.3

Table 5: Simulations with shocks to the lenders' risk aversion. We measure welfare gains as the constant proportional change in consumption of the private good that would leave domestic consumers indifferent between staying in the benchmark economy (without a fiscal rule) and moving to an economy with a fiscal rule, when $p = 0$.

lenders, Figure 12 shows that while the optimal debt-brake threshold changes almost one-to-one with the average debt level observed across economies without a fiscal rule, the optimal spread-brake threshold varies only between 0.6 and 1.2 percent.

9.1 How to mitigate concerns about exogenous spread volatility

Concerns about the effects of global factors on a country with a spread brake could be mitigated by targeting a "core" or "long-term" measure of the spread that is not affected by these factors.[20] This could be done by comparing the price of sovereign debt with the price of other assets also affected by global factors, including the price of debt issued by other countries. This is common practice in both academic and policy analysis. For instance, Neumeyer and Perri (2005) construct the country risk spread as the difference between two yields affected by global factors: the sovereign bonds yield and the yield of non-investment grade bonds in the United States. Juvenal and Wiseman (2015) distinguish between country-specific fundamentals and global and pan-European factors driving sovereign bond spreads to evaluate the merits of continued fiscal

[20]These concerns are similar to those about the effect of volatile exogenous factors on inflation in an inflation-targeting regime.

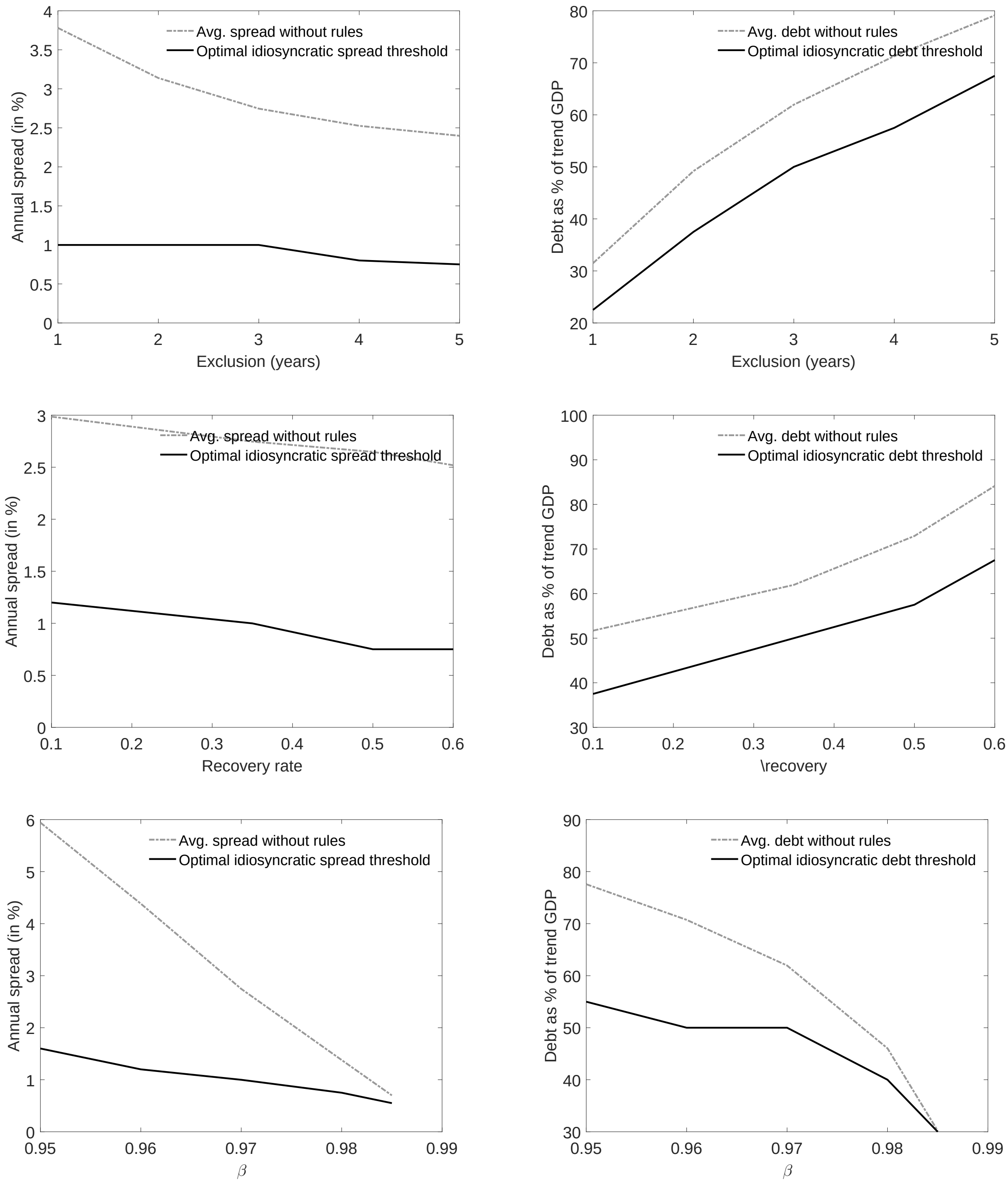

Figure 12: Average debt and spread levels and optimal rule thresholds in different economies with shocks to the lenders' risk aversion.

Set of economies with different	Exclusion duration	Recovery rate	Discount factor
	Optimal common limit		
Debt-brake threshold (in %)	50.00	58.00	50.00
Spread -brake threshold (in %)	1.00	1.00	1.20
	Welfare gains with common debt brake		
Average (in %)	0.20	0.18	0.35
Maximum (in %)	0.39	0.40	0.80
Minimum (in %)	0.00	0.00	0.09
	Welfare gains with common spread brake		
Average (in %)	0.28	0.29	0.37
Maximum (in %)	0.36	0.42	0.91
Minimum (in %)	0.20	0.17	0.08

Table 6: Welfare gains from common fiscal rules with shocks to the lenders' risk aversion.

consolidation in Portugal. They also identify that local factors would have tripled the spread in the run-up to the crisis but were obscured by positive global factors. The use of unobservable variables is common in fiscal rules that often use targets that are functions of potential GDP and/or long-term commodity prices. Independent fiscal councils are often in charge of determining the value of unobservable variables, improving the commitment to the fiscal rule.

In addition, a spread brake does not need to require the government to react to high-frequency changes in sovereign spreads. For instance, in each fiscal year, the spread brake could impose a limit to the fiscal balance when the average spread over the previous fiscal years was above the spread limit.

It is also difficult to argue that governments have more control over debt levels than over a "core" or "long-term" measure of the spread. For instance, countries often issue debt in foreign currency making the level of debt a function of the exchange rate and thus, putting it outside of the full control of the fiscal authority. In addition, contingent liabilities often imply large changes in debt levels, mostly outside the control of the government. Contingent liabilities are a standard component of the IMF debt sustainability analysis (IMF, 2013b). Bova et al. (2016)

present a dataset with the fiscal cost of contingent liabilities and their effect on debt levels.

10 Fiscal rules and the cyclicality of fiscal policy

We next discuss whether fiscal rules should allow for a larger government deficit in bad times. This is a central issue in discussions of fiscal rules in policy circles. "Escape clauses" that soften fiscal rules during recessionary periods are a component of many fiscal rules (Budina et al., 2012; Debrun and Kinda, 2014, Debrun et al., 2013; IMF, 2009; Schaechter et al., 2012). Our findings serve as a warning against promoting these clauses in the presence of sovereign risk: promoting a countercyclical fiscal policy reduces the volatility of consumption but does so at the cost of increasing default risk.

We focus on debt brakes. Since the sovereign spread changes with the state of the economy, focusing on debt brakes instead of spread brakes renders more transparent the discussion of how the limit imposed by the fiscal rule should be allowed to change over the business cycle.

We assume the debt-brake threshold is a linear function of the current TFP shock:

$$\bar{b}(z) = \bar{y}[a_0 + a_1(e^z - e^{\mu_z})], \tag{19}$$

where $\bar{y}$ is the average output level in the simulations of the benchmark economy.[21] We search for the optimal value of the coefficients a_0 and a_1.

We find that the optimal spread brake does not allow the debt-brake threshold to change over the business cycle: the optimal brake is the one discussed in Section 6, which corresponds to $a_0 = 2.1$ and $a_1 = 0$. Table 7 shows that a debt brake that better accommodates a more countercyclical fiscal policy by allowing the debt threshold to increase during economic downturns ($a_1 = -1$) will be successful in reducing the volatility of public and private consumption. However, this occurs at the expense of increasing the default frequency, in spite of the average debt level being lower. Since the cost of defaulting is lower during economic downturns (as reflected in countercyclical sovereign spreads), having higher debt levels during downturns imply a higher default frequency.

[21] Assuming that the debt limit is a function of output instead of TFP would allow the government to manipulate the limit with the tax rate, complicating the interpretation of the results.

	$a_1 = -1$	$a_1 = 0$	$a_1 = 1$
Mean debt-to-income ratio	53.3	54.9	54.0
Annual spread (in %)	0.8	0.5	0.4
Mean g/c (in %)	37.0	37.1	37.2
$\sigma(g)/\sigma(y)$	0.8	0.9	1.1
$\sigma(c)/\sigma(y)$	1.0	1.1	1.1
Defaults per 100 years	1.2	0.8	0.6
Welfare gain (in %)	0.2	0.5	0.4

Table 7: Simulation with a state-contingent debt threshold $\bar{b}(z) = \bar{y}[a_0 + a_1(e^z - e^{\mu_z})]$, for $a_0 = 2.1$.

Allowing for lower debt ceilings during downturns ($a_1 = 1$) has the opposite effects, i.e., it reduces the default frequency at the expense of increasing the consumption volatility.

Figure 3 shows that in the presence of default risk, it may be optimal for a government to sequentially choose a pro-cyclical fiscal policy. This section goes further, showing that, even when the government limits future policy choices with a fiscal rule, it may not want to use this rule to promote a countercyclical policy.

11 Optimal rules for indebted governments

This section discusses the introduction of a debt brake in states with positive debt. We focus on debt brakes because the spread brake does not impose a debt reduction in any period (i.e., it always allows the government to roll over debt), allowing for smooth transitions towards lower debt levels. In fact, as explained in Subsection 6.2, imposing the optimal spread brake produces welfare gains for all levels of debt. We show that introducing a debt brake in an indebted economy can generate significant welfare gains when the debt brake is complemented with a transition period. In order to lower the number of rules we have to study, we restrict our attention to debt-brake thresholds that do not depend on the TFP shock.

We assume that when the government introduces the debt brake it announces that the debt threshold $\bar{b}$ will be imposed in every period starting in period T. The government's maximization problem is not recursive until T. We solve the problem backwards, starting from the first period in which it becomes recursive. We search for the combination of $\bar{b}$ and T that maximizes welfare. Allowing for adjustment periods before the imposition of fiscal rule targets is common practice. For instance, Germany amended its constitution in 2009 to introduce a fiscal rule 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 assume that the initial debt level is 62 percent of the average output in the benchmark no-rule economy (the average debt level for that economy). We consider different levels of TFP for the period in which the rule is introduced.

We find that the initial TFP level does not significantly affect the rule to which the government would like to commit: in all cases welfare is maximized with a debt limit of 60 percent (of the average output in the benchmark no-rule economy), and a transition of 5 (8) quarters when the initial TFP is one standard deviation above (below) the mean. Welfare gains from introducing the debt brake are between 0.6 and 0.8 percent, depending on the initial level of TFP.

Figure 13 presents the mean spread level after the optimal rule announcement. The figure shows that the optimal fiscal rule implies a substantial reduction of the spread, even though the debt limit (60 percent) is very close to the initial debt level (62 percent). This happens because part of the cost of defaulting is the loss of access to debt markets, and this cost is higher when debt markets are more attractive. Since the fiscal rule makes debt markets more attractive (by mitigating the debt dilution problem, and thus allowing the government to borrow at a lower rate; Figure 4), the rule increases the cost of defaulting, allowing the government to borrow more (for a given interest rate). Figure 13 also shows that the spread declines immediately with the rule announcement (before any debt reduction takes place), reflecting the expectation of future debt reductions. This implies that the level of indebtedness could be reduced without any fiscal sacrifice (by not spending all the resources saved in interest payments).

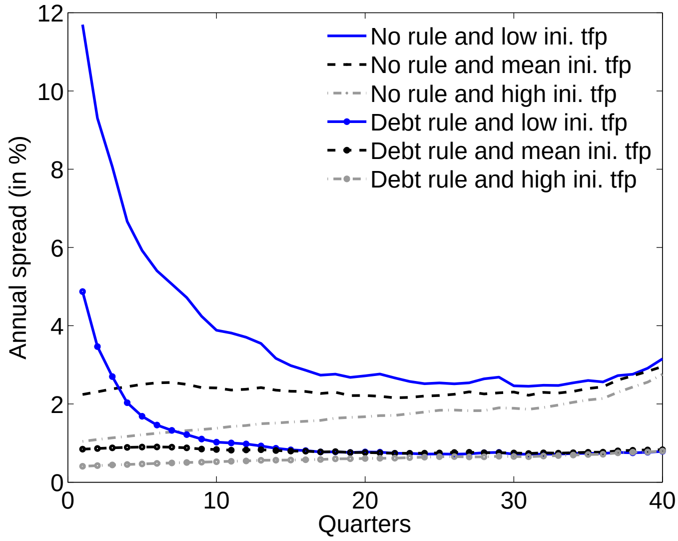

Figure 13: Spread during transitions that follow the announcement of the optimal debt brake, for samples without defaults.

12 A no-default rule

In this section, we discuss a rule that would force the government to pay its debt, eliminating sovereign defaults. Since the dynamic inefficiencies that account for the gains to be had from introducing a fiscal rule arise because of default risk, it may seem natural to attack these inefficiencies directly by eliminating the possibility of default. However, we show that a rule that eliminates the possibility of default may be difficult to enforce, as the temptation of abandoning it would be large. This is consistent with the rarity of fiscal rules intending to eliminate the possibility of defaulting (the IMF fiscal rule database presents a thorough description of fiscal rules around the world; see Budina et al., 2012; IMF, 2009; Schaechter et al., 2012). This is also in contrast with the government's willingness to keep the optimal spread brake discussed in Subsection 6.2.

In order to study the economy with the no-default fiscal rule, we introduce an exogenous borrowing limit. Recall that in the no-rule model borrowing is endogenously limited by the possibility of default (Figure 4). A fiscal rule eliminating this possibility removes this endogenous borrowing constraint, creating the need for an exogenous borrowing limit. In particular, we assume that in the no-default economy, the government cannot borrow more than fifteen times the low (one standard deviation below the mean) output in the benchmark no-rule economy. Since we strip the model from default risk, there is no difference between short- and long-term debt. Therefore, we solve and simulate the following problem:

$$
\begin{aligned}
& W(b,z) = \max_{b'\geq 0, c\geq 0, g\geq 0, \tau\geq 0} \left\{ u\left(c,g,1-l\right) + \beta \mathbb{E}_{z'|z} W(b',z') \right\}, \\
& \text{subject to} \\
& g = \tau e^{z} l - b + \frac{b'}{1+r}, \\
& c = (1-\tau) e^{z} l, \\
& l = \hat{l}\left(z,\tau,c,g\right) \\
& b' \leq \bar{b}.
\end{aligned}
$$

We measure the gain that results from abandoning the no-default rule in any period. When the government abandons the fiscal rule, it returns to the benchmark no-rule economy described in Subsection 3.2.

In order to perform this exercise, we need to make an assumption about the recovery rate for the debt that the government defaults on when it deviates from the no-default rule. It is not obvious which recovery rate would be reasonable for the high debt levels in the no-default economy. For that reason, we solve the model for two recovery rates: zero and 12 percent. These values imply a mean debt level in the simulations that is almost four times annual output. For such high debt levels, the 12 percent recovery rate already implies a very high post-default debt level. Assuming a higher recovery rate would force us to solve the default model for a very wide range of debt levels, which would be computationally costly. All other parameter values are as in the benchmark calibration. We find that the assumed recovery rate does not change significantly the gains from abandoning the no-default rule.

We measure the gain from abandoning the no-default rule as the one-time TFP loss (that does not affect the distribution of TFP in future periods) implied by abandoning the rule that would make the representative household indifferent between keeping the rule and abandoning it. For all states in the simulations of the economy with the fiscal rule, we compute the output loss implied by this TFP decline in the no-rule economy. We express the output loss as a fraction of mean annual output.

Formally, we first find the value of abandoning the fiscal rule for any implied one-time TFP loss x,

$$\hat{V}^D(\hat{\alpha}b, z, x) = \max_{c\geq 0, g\geq 0, \tau\geq 0} u\left(c, g, 1-l\right) + \beta \mathbb{E}_{z'|z}\left[(1-\xi)V^D(\alpha\hat{\alpha}b(1+r), z') + \xi V(\hat{\alpha}b(1+r), z')\right]$$

subject to

$$g = \tau x\left[e^z - \phi(\hat{z})\right] l,$$

$$c = (1-\tau)x\left[e^z - \phi(\hat{z})\right] l,$$

$$l = \hat{l}\left(log(x) + log(e^z - \phi(z)), \tau, c, g\right),$$

where $\hat{\alpha}$ denotes the debt reduction the government obtains when it abandons the rule and defaults. Then, for each (b, z) in the simulations of the economy with the no-default fiscal rule, we find the value of x that makes the representative household indifferent between continuing with the fiscal rule and abandoning it (this is, for the no-default rule, we find x such that $W(b, z) = \hat{V}^D(\hat{\alpha}b, z, x)$).

We find that the cost of enforcing the no-default rule would be large: the maximum gain from abandoning the rule is equivalent to between 12.3 and 12.4 percent of annual output, depending on the assumed debt reduction obtained by the defaulting government $\hat{\alpha}$. The median gain is between 11.5 and 11.6 percent. A large gain from abandoning a no-default fiscal rule is intuitive. If a no-default rule removes the borrowing constraint implied by default risk, a government eager to borrow would accumulate a high level of debt, for which the temptation of abandoning the rule and defaulting would be large. Therefore, it is difficult to imagine that a government could credibly commit to a no-default rule.

13 Conclusions

It is often recognized that discussions of fiscal policy lack an anchor to manage expectations about future policies (Leeper, 2010). The findings presented in this paper suggest that the unstable relationship between sovereign debt levels and sovereign risk provides a rational for a greater role of sovereign spreads as fiscal policy anchors.

We use a sovereign default model to search for a common fiscal rule that maximize welfare for sets of heterogeneous model economies. We find that compared with a common debt-brake rule, a common spread-brake rule generates larger welfare gains. This is intuitive. Economies should be allowed to issue more debt when they suffer less of a debt intolerance problem. A common spread brake allows for this whereas a common debt brake does not. Since levels of debt intolerance are difficult to identify, and seem to vary greatly both across countries and over time, a spread brake is likely to perform better than a debt brake.

We see advantages of market determined fiscal rule targets over debt targets even beyond the ones discuss in the paper. For instance, market determined targets could be less susceptible to creative accounting. Furthermore, several debt characteristics beyond the debt level (for instance on debt maturity and currency composition) influence country risk and are also likely to be affected by time inconsistency problems (these characteristics are a standard component of debt sustainability analysis; IMF, 2013b). Market determined targets are more likely to provide a comprehensive measure of fiscal risks.

There are several interesting issues concerning the practical implementation of a spread brake that are beyond the scope of this paper. For instance, should a spread brake target a "core" spread that is less affected by global factors? The average spread over which period should be used to trigger the spread brake? When the spread is above the brake threshold, should the government be allowed to rollover debt or should it be forced to reduce its debt level? How much debt should a government be allowed to rollover? Our analysis suggests that spread brakes are worth considering and, thus, answering these questions should be promising avenues for future research.

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