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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 threshold. 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 welfare gains than a common debt brake. This suggests that when political constraints force common fiscal targets across economies, 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

This paper illustrates the importance of two issues sometimes overlooked in discussions of fiscal policy: the management of expectations about future budget balances, and choosing the appropriate planning instruments under heterogeneity and risk and uncertainty. It is often recognized that fiscal policy frameworks lack an anchor that improves commitment to 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 moral hazard, government myopia, or time inconsistency problems. Fiscal anchors could be particularly useful when deleveraging is needed and in periods of public debt expansions.[1] This paper illustrates how substantial gains could be achieved by introducing simple fiscal rules that implement fiscal anchors.

The paper brings to fiscal policy the discussion of whether prices or quantities are the best planning instrument under heterogeneity and risk and uncertainty (Weitzman, 1974). While debt levels play a predominant role in discussions of fiscal policies, we show that the sovereign spread (i.e., the difference between a sovereign bond yield and a risk-free interest rate) is better suited to be the fiscal anchor. Our results are consistent with those presented by Weitzman (1974). When there is heterogeneity in costs (sovereigns facing different borrowing costs for the same debt level), it is better for the planner (the authority implementing a supranational fiscal rule) to choose as its instrument a price (the sovereign bond price reflected in the spread) instead of a (debt) quantity. Similarly, risk or uncertainty (as defined by Hansen and Sargent, 2008) about costs also make prices a superior instrument. In the monetary policy context, it has long been argued that the variability of the demand for money makes the interest rate a superior policy instrument over the money stock (Poole, 1970). We argue that the variability of the demand for sovereign debt makes the spread a superior policy instrument over the debt level. Our results are also related to the preference for policies that are robust to model misspecification (Hansen and Sargent, 2008).

As defined by the IMF (2017), "A fiscal rule is a long-lasting constraint on fiscal policy

[1] Bi et al. (2013) show that expectations about future fiscal consolidations are an important determinant of the success of fiscal adjustments.

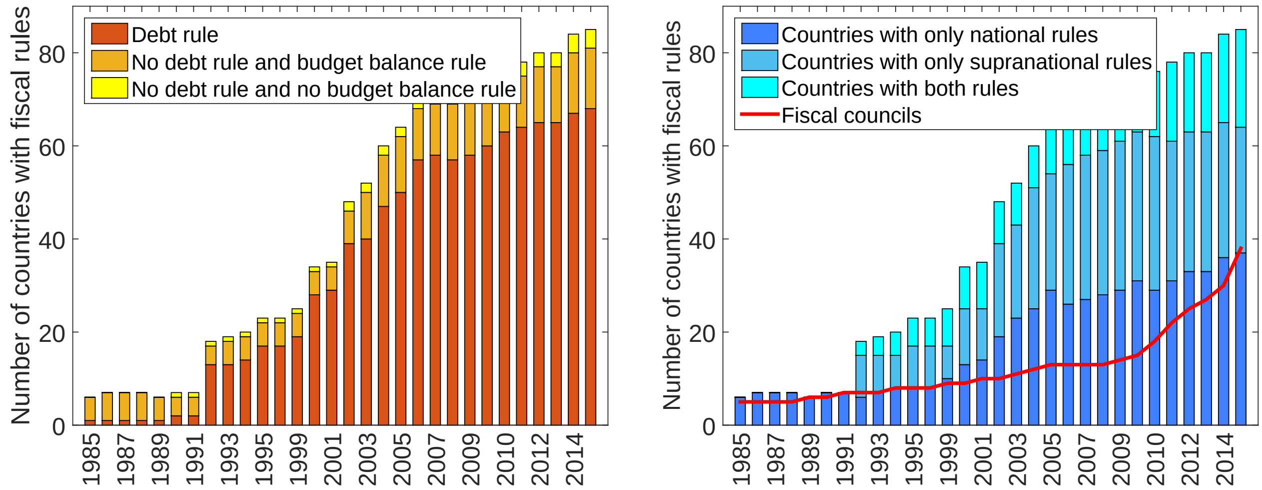

Figure 1: Number of countries with fiscal rules and fiscal councils. Source: IMF Fiscal Rules and Fiscal Councils datasets.

through numerical limits on budgetary aggregates. This implies that boundaries are set for fiscal policy which cannot be frequently changed." By setting long-lasting constraints, fiscal rules can play a central role in managing expectations about future policies. At the same time, the need for constraints to be long-lasting limits the possibility of adapting fiscal rules as uncertainty is revealed, highlighting the importance of studying the design of fiscal rules under uncertainty, underscored in this paper.

Figure 1 shows that an increasing number of countries is adopting fiscal rules. The left panel shows that the bulk of countries adopting fiscal rules are limiting the debt level.[2] The right panel shows that many fiscal rules are supranational (e.g., 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.[3] 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

[2] 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.

[3] Following Aguiar and Gopinath (2006) and Arellano (2008), the Eaton and Gersovitz' (1981) framework is commonly used for quantitative studies of fiscal policy and sovereign debt crises.

sovereign debt and the sovereign default premium (Chatterjee and Eyigungor, 2012; Hatchondo and Martinez, 2009).[4]

Within this framework, we focus on two fiscal rules. First, we study rules that mimic the ones countries implement, using as an anchor for future fiscal policy the level of debt (left panel of Figure 1): a debt-brake rule imposes a ceiling on the fiscal budget balance to prevent the sovereign debt level from exceeding a threshold. We discuss the benefits and limitations of these commonly used rules. Second, we propose spread-brake rules that are essentially equivalent to existing debt brakes with the only exception of using a sovereign spread threshold instead of a debt threshold for triggering a limit on the fiscal balance. In this respect, we are following the literature discussing differences between prices and quantities as planning instruments. As explained by Weitzman (1974), "The reason we specialize to price and quantity signals is that these are two simple messages, easily comprehended, traditionally employed, and frequently contrasted." He also argues that "There are real costs associated with using more complicated signals." These arguments are common in the context of fiscal rules. For example, Wyplosz (2012) argues that "The presumption is that rules should be simple to be understood by policymakers and citizens alike" and that "The success of the Swiss debt brake (so far) derives from the simplicity of the rule."

We first show how introducing a fiscal rule mitigates the debt dilution problem and thus expands the government's borrowing set (i.e., it allows the government to sell the same number of bonds at a higher price), generating welfare gains. We also show that for any single economy, and without uncertainty about the characteristics of this economy, similar gains can be obtained with either a debt or a spread brake.

We then search for a common fiscal rule that maximizes welfare for a set of model economies

[4]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.

with different levels of debt intolerance (i.e., different mappings from sovereign debt to the sovereign default premium).[5] 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 of 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). Furthermore, common fiscal rules are often imposed to subnational governments in the same country. More generally, international financial organizations often use common fiscal targets to guide policy advice.[6]

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 example, the sovereign spread in Croatia was 3.9 percent in 2000 for a debt level of 33 percent, and 3.0 percent in 2015 for a debt level of 87 percent. Structural changes introduce a tension in the design of fiscal rules. On the one hand, as mentioned above, an effective fiscal rule need to establish boundaries that cannot be frequently changed. On the other hand, we would like rules to accommodate 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

[5]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 optimal spread levels, they could present a bigger challenge for a common spread brake. We show that this is not the case.

[6]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).

common spread brake generates larger welfare gains than the optimal common debt brake. This result is intuitive. On the one hand, a low debt threshold that is binding in economies with high debt intolerance (that feature lower debt levels) imposes an unnecessarily tight borrowing constraint and thus welfare losses to economies with low debt intolerance (that can borrow more without facing default risk). On the other hand, a high debt threshold that does not impose an unnecessarily tight borrowing constraint to economies with low debt intolerance, fails to impose a binding constraint to economies with high debt intolerance and, therefore, does not generate welfare gains in these economies. This makes debt limits ineffective as common and robust fiscal anchors. 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, it forces economies with more debt intolerance to borrow less while allowing economies with less debt intolerance to borrow more.

We also show that it may be difficult to generate ownership of a common debt brake in a union of heterogeneous economies. In order to generate welfare gains (or reduce default risk because of moral hazard concerns) in higher debt intolerance economies in a union (e.g., Greece or Portugal), a common debt brake needs to impose a low debt threshold. In turn, this threshold may impose large welfare losses in lower debt intolerance economies (e.g., France). Consequently, the latter economies may have strong incentives to abandon the common threshold, weakening the commitment of the union to the fiscal rule.

Our findings highlight significant limitations to the widespread use of debt limits to anchor discussions of fiscal policy. 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). However, significant uncertainty remains about the optimal value of debt targets. For example, the IMF flagship fiscal publication (IMF, 2013a) stated that "the optimal-debt concept has remained at a fairly abstract level, whereas the safe-debt concept has focused largely on empirical applications", where safe debt levels are those less correlated with the occurrence of crises. IMF (2013a) also acknowledges that "the appropriate debt target need not be the same for all countries".[7]

Our findings suggest that the unstable relationship between sovereign debt levels and sovereign risk provides a rationale for shifting 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.

The role of interest rates in policy debates 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 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 level of scrutiny in surveillance (IMF, 2013b). 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). In 1998, in an attempt to show commitment to lower levels of sovereign risk, Argentina issued bonds with floating rates based on the market yield of other fixed-rate Argentine debt. The U.S. government issued similar bonds during World War I, and Italy did the same during the 1980s debt crisis (Alesina et al., 1990). Hatchondo et al. (2016) discuss potential benefits of issuing such bonds.

Of course, several issues need to be considered for the successful use of sovereign spreads as fiscal anchors. Every year when the government's budget is decided, 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). Measures of the domestic component of the spread (Juvenal and Wiseman, 2015) could be used to avoid reactions to changes in global factors (even though Appendix B indicates

[7] 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).

that spread brakes perform well even in the presence of global shocks). To avoid a bias towards procyclical fiscal policy, spreads brake could limit only the budget balance during economic booms, as debt brakes often do in practice (even though Section 5 indicates that a spread brake may not lead to a more procyclical fiscal policy).

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. But in general, it is difficult to argue that there is no valuable information in sovereign spreads.

1.1 Related Literature

Chatterjee and Eyigungor (2015) and Hatchondo et al. (2016) propose modifying sovereign debt contracts to deal with the debt dilution problem. Chatterjee and Eyigungor (2015) study the effects of introducing a seniority structure, and Hatchondo et al. (2016) study the effects of introducing debt covenants that penalize future borrowing. We propose using fiscal rules.

We see these proposals for dealing with dilution as complementary and the study of the complementarities of these proposals as an interesting avenue for future research. In particular, Hatchondo et al. (2016) 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. Hatchondo et al. (2016) do not discuss those cases. Thus, our results could inform the design of the debt covenants presented by Hatchondo et al. (2016).

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 (2015) 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. Appendix D shows 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. Appendix D shows that in the data 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) discusses 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 Ayres et al. (2015) and 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. While we do no study multiple equilibria, eliminating bad equilibria à la Calvo could present additional gains from establishing spread rules.

The rest of the article proceeds as follows. Section 2 presents a three-period model that illustrates how a common spread brake may outperform a common debt brake. Section 3 introduces the quantitative model. Section 4 discusses the benchmark calibration. Section 5 presents the optimal debt and spread brakes for the benchmark calibration. Sections 6 and 7 show that a spread brake is a better common rule for sets of heterogeneous model economies. Section 8 discusses commitment to fiscal rules. Section 9 concludes. The Appendix shows that (i) a common spread brake continues to outperform a common debt brake when global shocks affect the spread, (ii) it would be difficult to commit to a no-default rule, (iii) welfare gains from introducing fiscal rules are larger when we assume political myopia, (iv) the government may not want to use fiscal rules to promote countercyclical fiscal policy, and (v) in an indebted economy, introducing an idiosyncratic debt brake with a transition period generates welfare gains.

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. Proofs of the propositions are presented in the Appendix.

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 $y_3 \geq 0$. 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 $y_3 \geq 0$. Let σ_y denote the standard deviation of y_3. Let u denote the strictly increasing and concave utility function, $c_t \geq 0$ denote period-t consumption, $\beta < 1$ denote the government's discount factor, and $\mathbb{E}$ denote 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.[8] If the government defaults, it does not pay its debt but looses a fraction $\phi > 0$ of the period-3 endowment y_3. Bonds are priced by competitive risk-neutral investors who discount future payments at a rate of 1.

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 ($\beta < 1$) or has a strictly concave utility function. However, the borrowing choices available to the government are restricted by a limited commitment problem.

Let b_t denote the number of bonds issued by the government in period t. The equilibrium default decision of the period 3 government is given by

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

where $\hat{d}(b_1, b_2, y_3) = 1$ $(= 0)$ if the government defaults (pays its debt). Given the above defaulting rule, the price of a bond issued in period 1 is given by

$$q_1(b_1, b_2) = \delta + (1-\delta)\left[1 - F\left(\frac{b_1(1-\delta)+b_2}{\phi}\right)\right]. \tag{2}$$

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

$$q_2(b_1, b_2) = 1 - F\left(\frac{b_1(1-\delta)+b_2}{\phi}\right). \tag{3}$$

The equilibrium levels of consumption are

$$\begin{aligned} c_1(b_1, b_2) &= b_1 q_1(b_1, b_2), \\ c_2(b_1, b_2) &= b_2 q_2(b_1, b_2) - \delta b_1, \\ c_3(b_1, b_2, y_3) &= y_3[1 - \hat{d}(b_1, b_2, y_3)\phi] - [1 - \hat{d}(b_1, b_2, y_3)][b_1(1-\delta) + b_2]. \end{aligned} \tag{4}$$

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

Let $\{b_1^R, b_2^R\}$ denote the sequence of borrowing that maximizes the government's expected utility in period 1, given that the default rule of the period 3 government in equation (1). This is, $\{b_1^R, b_2^R\}$ solves

$$\underset{b_1,b_2}{Max} \quad u\left(c_1(b_1,b_2)\right) + \beta u\left(c_2(b_1,b_2)\right) + \beta^2 \mathbb{E}[u\left(c_3(b_1,b_2,y_3)\right)]$$
$$s.t.\ c_t \geq 0 \text{ for } t = 1,2,3.$$

We refer to $\{b_1^R, b_2^R\}$ as Ramsey policies.[9]

Let $\{b_1^M, b_2^M(b_1^M)\}$ denote the sequence of borrowing chosen sequentially by the governments in periods 1 and 2. We refer to $\{b_1^M, b_2^M(b_1^M)\}$ as Markov policies. For any b_1, the period 2 Markov strategy b_2^M solves

$$\underset{b_2}{Max} \quad u\left(c_2(b_1,b_2)\right) + \beta \mathbb{E}[u\left(c_3(b_1,b_2,y_3)\right)]$$
$$s.t.\ c_t \geq 0 \text{ for } t = 2,3.$$

The period 1 Markov policy b_1^M solves

$$\underset{b_1}{Max} \quad u\left(c_1(b_1,b_2^M(b_1))\right) + \beta u\left(c_2(b_1,b_2^M(b_1))\right) + \beta^2 \mathbb{E}[u\left(c_3(b_1,b_2^M(b_1),y_3)\right)]$$
$$s.t.\ c_t \geq 0 \text{ for } t = 1,2,3.$$

Proposition 1 shows that when the government issues one-period debt, Ramsey policies coincide with Markov policies and, therefore, there is no role for fiscal rules.

Proposition 1 *Suppose $\delta = 1$; i.e., bonds issued in period 1 pay off in period 2 alone. Then, Markov policies coincide with Ramsey policies (and thus there is no need for fiscal rules).*

Proposition 2 shows that when the government issues long-term debt, Ramsey policies do not coincide with Markov policies. Because there is default risk in equilibrium, long-term debt

[9]Note that b_2^R is the level of period 2 borrowing the period 1 government would like to commit to, if it cannot commit to a period 3 default decision. Appendix C discusses commitment to a no-default rule.

creates the debt dilution problem. 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 2). Ramsey policies take into account that the price of the debt issued in period 1 is negatively affected by debt issuances in period 2. But this is not a cost for the sequential government acting in period 2 and thus is not a consideration for Markov policies. Consequently, 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 1 implies that the default probability is increasing with respect to b_2).

Proposition 2 *Suppose $\delta < 1$; i.e., the government issues long-term debt in period 1. Then, Markov policies and Ramsey policies do not coincide.*

We study two ways of imposing a limit on government's choices in period 2. First, using a debt-brake rule that imposes a ceiling on the debt level, $(1-\delta)b_1 + b_2 \leq \bar{b}$. Second, using a spread-brake rule that 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, committing to any of these two fiscal rules is sufficient for making the sequential government choose Ramsey policies.

Proposition 3 *If the government's choices in period 2 are limited with either a debt brake with threshold $\bar{b}^* = (1-\delta)b_1^R + b_2^R$ or a spread brake with threshold $\underline{q}^* = q_2(b_1^R, b_2^R)$, Markov policies coincide with Ramsey policies.*

Proposition 3 explains that imposing a limit (to either the amount borrowed or the interest rate paid) can force the sequential government to choose the Ramsey policies. Note that using a limit instead of prescribing the policy (either the amount borrowed or the interest rate paid) is inconsequential in this environment. Proposition 3 can thus be interpreted as saying that having a debt or an interest rate instrument is inconsequential for a Ramsey planner. This is the standard result of equivalency of between prices and quantities as planning instruments without uncertainty (Weitzman, 1974), including the use of the interest rate or the money stock as the monetary policy instrument (Poole, 1970). In contrast, the next subsection shows that, as the common rule for a set of heterogeneous economies, imposing a limit is better than prescribing a policy, and a spread brake performs better than a debt brake.[10]

2.3 Optimal common fiscal rule for a set of heterogeneous economies

Consider a set of heterogenous economies indexed by the value of the parameter $\theta \in \{\phi, \sigma_y, \beta\}$, and a constrained Ramsey planner that must apply the same policy to every economy in the set. There are two interpretations of the constrained Ramsey policy. First, it could be the policy chosen by a Ramsey planner constrained to choosing the same policy for a set of heterogeneous economies. For example, political constraints may force a supranational authority in a union of countries to impose the same fiscal rule to all countries in the union. Second, the constrained Ramsey policy could be chosen by a planner for a single economy, when the planner is constrained to committing to a policy without knowing the value of the parameter θ. One could think that the policy could be changed after learning θ. However, as mentioned in the introduction, an essential characteristic of effective fiscal rules is that they cannot be frequently changed. Having either heterogeneity or risk or uncertainty is essential for the tradeoffs of using prices or quantities as planning instruments (Poole, 1970; Weitzman, 1974).

2.3.1 Optimal common fiscal rule and debt intolerance

We first focus on sets of economies that differ only in the level 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 the same level of debt; see equations 2 and 3). We can expect the borrowing level under Ramsey policies to be increasing with respect to ϕ (i.e., everything else equal, it is optimal to borrow more when the cost of borrowing is lower). For simplicity, Proposition 4 presents sufficient conditions under which the borrowing level under Ramsey policies is

[10] It should also be noticed 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) and Hatchondo and Martinez (2013) present models of sovereign default and endogenous debt maturity in which plausible calibrations of rollover risk deliver the 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.

proportional to ϕ. In Proposition 4, the next assumption is a sufficient condition for the existence of a unique Ramsey policy for each level of ϕ.

Assumption 1: The function

$$\zeta_q(b) = \frac{b}{\phi} \frac{f\left(\frac{b}{\phi}\right)}{1 - F\left(\frac{b}{\phi}\right)}$$

is increasing with respect to b, $\lim_{b \to 0} \zeta_q(b) = 0$, and $\lim_{b \to \infty} \zeta_q(b) \geq 1$. The function ζ_q is the absolute value of the elasticity of the (period 2) bond price with respect to the debt level b. Thus, Assumption 1 states that the bond price is more responsive to changes in the debt level for higher debt levels.

Proposition 4 *Suppose $u(c) = c$, $\delta = 0$, and Assumption 1 holds. Consider any set of economies that are different only in the value of the cost of defaulting ϕ. Then, Ramsey policies are given by $\{b_1^R = \eta\phi, b_2^R = 0\}$, where $\eta \in \mathbb{R}_{++}$ satisfies*

$$1 - \eta \frac{f(\eta)}{1 - F(\eta)} = \beta^2. \tag{5}$$

We define a common debt brake as a rule imposing to all economies in the set a common debt ceiling $\bar{B}$ such that $(1-\delta)b_1 + b_2 \leq \bar{B}$. A common spread brake imposes to all economies in the set a common ceiling on the spread paid by the government in the second period, and thus it imposes a floor $\underline{Q}$ on the sovereign bond price, such that $q_2(b_1, b_2) \geq \underline{Q}$.

Note that since the Ramsey debt level $b_1^R = \eta\phi$ is increasing in the cost of defaulting ϕ, a common debt-brake threshold $\bar{B}$ cannot achieve the Ramsey allocation in every economy in the set. 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. And a common debt brake cannot achieve this.

A common spread brake performs better: the same spread limit allows economies with less debt intolerance to borrow more while forcing economies suffering more debt intolerance to borrow less. Under the assumptions in Proposition 4, the bond price implied by the Ramsey debt level is the same in all economies $(1 - F(\eta))$. Therefore, the optimal common spread-brake threshold is given by this bond price ($\underline{Q}^* = 1 - F(\eta)$) and delivers the Ramsey allocation for every economy in the set. 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. This is summarized in the following proposition.

Proposition 5 *Suppose $u(c) = c$, $\delta = 0$, and Assumption 1 holds. Consider any set of economies that are different only in the value of the cost of defaulting ϕ. The optimal common spread-brake threshold for any such set is $\underline{Q}^* = 1 - F(\eta)$ and achieves the Ramsey allocation in every economy of the set, with η given by equation (5). Furthermore, $\underline{Q}^*$ generates larger welfare gains than any common debt brake $\bar{B}$.*

Proposition 5 brings to fiscal policy a standard result in the prices vs. quantities debate. When there is heterogeneity in costs (in this case in the cost of borrowing), using a price (the bond price) allows the planner to encourage low-cost agents to choose larger quantities (more borrowing) while forcing high-cost agents to choose lower quantities (Weitzman, 1974). Similarly, when costs are not known, prices are a superior instrument (Weitzman, 1974).

Note also that Proposition 5 holds for any distribution of weights assigned by the planner to the heterogenous economies in the set. That is, the optimal common spread brake is superior to any common debt brake for any distribution of weights. Furthermore, the optimal common spread brake with threshold $\underline{Q}^* = 1 - F(\eta)$ is the same for any distribution of weights, and thus can be found without knowledge of this distribution and is a robust policy as described by Hansen and Sargent (2008). Clearly, since the Ramsey debt level $b_1^R = \eta\phi$ is a function of ϕ, the optimal common debt brake depends on the distribution of weights. Section 7 discusses further the greater robustness of the common spread brake to changes in the objective of the planner.

2.3.2 Optimal common fiscal rule and debt intolerance: numerical examples

We next present numerical examples that relax some of the assumptions in propositions 4 and 5. Nevertheless, the optimal common spread brake still outperforms the optimal common debt brake. This illustrates how the forces behind these results apply beyond the specific assumptions in the propositions.

Assume $u(c) = -c^{-1}$, $log(y_3) \sim N(0, \sigma_y)$, $\delta = 0$, and $\beta = 1$ (since the utility function is strictly concave, we no longer assume $\beta < 1$ to guarantee the government wants to borrow in

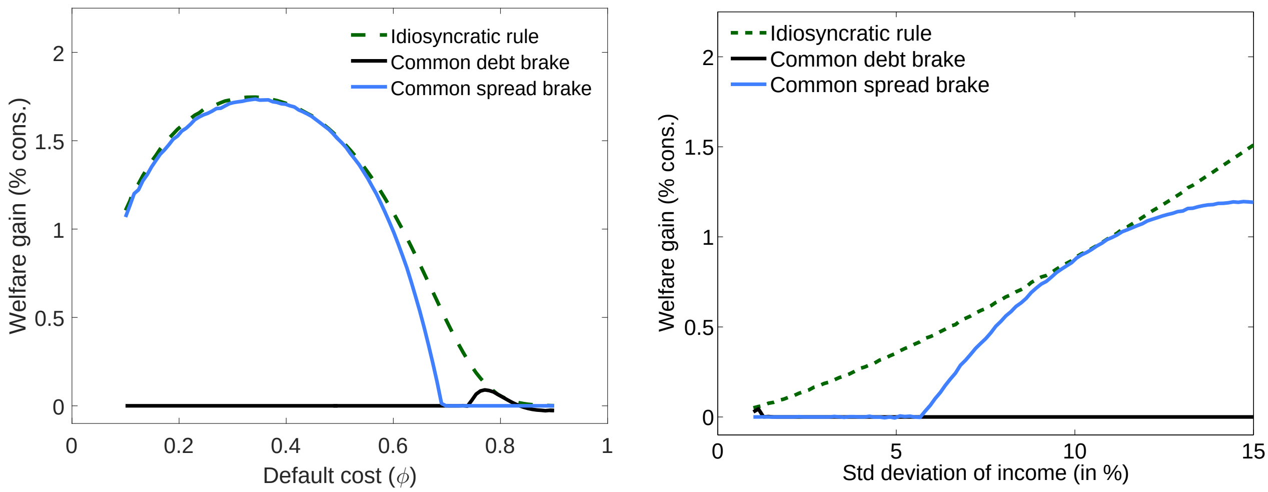

Figure 2: Welfare gains from imposing the optimal fiscal rule.

period 1). We find the constrained Ramsey policy that maximizes the average period 1 expected utility assigning weight $h(\theta)$ to the economy with parameter value θ. We consider two sets of economies with the planner assigning uniform weights to the heterogenous parameter: (i) $\sigma_y = 0.1$ and $\phi \sim h(\phi) = U[0.1, 0.9]$, and (ii) $\phi = 0.5$ and $\sigma_y \sim h(\sigma_y) = U[0.01, 015]$. Without a fiscal rule, 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 either a lower ϕ or a higher σ_y) pay higher spreads for lower debt levels (even though within each economy higher debt levels imply higher spreads).

Figure 2 shows that the optimal common spread brake outperforms the optimal common debt brake. In fact, in most economies, the optimal common debt brake does not generate any welfare gain. This is because the optimal common debt brake avoids borrowing constraints that are too tight for low debt intolerance economies (with a high cost of defaulting or a low volatility of income). Since governments do not receive income in the first two periods and thus are eager to borrow, borrowing constraints that are too tight are costly. In order to avoid borrowing constraints that are too tight for low debt intolerance economies, the optimal common debt brake cannot impose a binding constraint in economies with higher debt intolerance (that choose lower debt levels). Thus, the optimal common debt brake fails to generate significant welfare gains.

As the optimal common debt brake, the optimal common spread brake avoids borrowing constraints that are too tight for low debt intolerance economies (i.e., with either a higher ϕ or a lower σ_y). Welfare gains are zero for these economies. Nevertheless, in contrast with the optimal common debt brake, the optimal common spread brake generates significant welfare gains in economies with higher debt intolerance. This occurs because a spread threshold that is not binding in low debt intolerance economies can still be binding in high debt intolerance economies (that pay higher spreads). In contrast, a debt threshold that is not binding in low debt intolerance economies cannot be binding in high debt intolerance economies (that have lower debt levels).

Figure 2 also illustrates how imposing a limit is better than prescribing a policy. In the figure, the optimal common spread-brake threshold $\underline{Q}^*$ is not binding for the economies with less debt intolerance that choose to pay a spread lower than the one implied by $\underline{Q}^*$, both with and without the fiscal rule. Thus, welfare gains from imposing the common spread brake are zero for these economies. Note however that if instead of imposing a spread limit the fiscal rule forces all economies to pay the same spread, forcing the economies with less debt intolerance to pay the spread implied by $\underline{Q}^*$ would generate welfare losses for these economies.

2.3.3 Optimal common fiscal rule and the governments' patience

This subsection focuses on sets 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. Proposition 5 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 $\underline{Q}^* = 1 - F(\eta)$). Nevertheless, in sets of economies with different β, it is optimal for a more impatient government to pay a higher spread. Would a common spread brake be outperformed by a common debt brake in such sets of economies? The next proposition shows that it would not.

Proposition 6 *For any set of economies that differ only in the value of β, for each economy in* *the set, the optimal common debt-brake threshold* $\bar{B}^*$ *generates the same welfare gain than the optimal common spread-brake threshold* $\underline{Q}^* = 1 - F\left(\frac{\bar{B}^*}{\phi}\right)$.

The key assumption for the result in Proposition 6 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 common debt brake there is a common spread brake that imposes the same constraint in every economy in the set. 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.

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 TFP e^z and labor hours l. The logarithm of domestic TFP follows an AR(1) process:

$$z_t = (1 - \rho)\,\mu_z + \rho z_{t-1} + \varepsilon_t, \tag{6}$$

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 β denotes 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

$$\max_{l} u\left(c, g, 1-l\right) \tag{7}$$
$$\text{subject to}$$
$$c = e^{z}(1-\tau)l,$$

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 the public good or distortionary taxes.

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. (2016) 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 $\phi\left(z\right)$ in every exclusion period.

Following Hatchondo et al. (2016), 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. (2016), 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 (we show in the appendix that our main results are robust to introducing shocks to the lenders' risk aversion) 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). Households choose consumption and labor.

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:

$$V(b,z) = \max\left\{V^R(b,z), V^D(b,z)\right\}, \tag{8}$$

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:

$$V^R(b,z) = \max_{b'\geq 0, g\geq 0, \tau\geq 0} \left\{ u\left(c,g,1-l\right) + \beta \mathbb{E}_{z'|z} V(b',z') \right\}, \tag{9}$$

subject to

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

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

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

$$q\left(b',z\right) \geq \underline{q} \text{ if } b' > b, \tag{10}$$

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 7).

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:

$$V^D(b,z) = \max_{g\geq 0, \tau\geq 0} u\left(c,g,1-l\right) + \beta \mathbb{E}_{z'|z}\left[(1-\xi)V^D(b(1+r),z') + \xi V(\alpha b(1+r),z')\right], \tag{11}$$

subject to

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

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

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

Competitive bond markets imply that

$$q(b',z)(1+r) = \mathbb{E}_{z'|z}\left[\hat{d}\left(b',z'\right)(1+r)q^D(b'(1+r),z') + \left[1-\hat{d}\left(b',z'\right)\right]\left[1+(1-\delta)\,q(\hat{b}(b',z'),z')\right]\right], \tag{12}$$

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

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

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 $\{\hat{g}^R,\hat{g}^D\}$, taxes $\{\hat{\tau}^R,\hat{\tau}^D\}$, and labor $\hat{l}$,
2. a bond price function q,

such that:

(a) given a bond price function q; the policy functions $\hat{d}$, $\hat{b}$, $\hat{g}^R$, $\hat{g}^D$, $\hat{\tau}^R$, $\hat{\tau}^D$, $\hat{l}$ solve the Bellman equations (8), (9), and (11), and the households' problem in (7).

(b) given $\hat{d}$ and $\hat{b}$, the bond price function q satisfies equation (12).

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 (9).[11]

A spread-brake rule imposes a ceiling on the fiscal budget balance that prevents the government from increasing its debt level in a way that pushes the sovereign spread beyond a threshold.

[11]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).

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 (10). Note that equation (10) 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 would be higher than the brake threshold. 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 determined by $\underline{q}$.

4 Benchmark calibration

We first present a benchmark calibration. It should be emphasized that while we find plausible parameter values for the benchmark calibration, we acknowledge uncertainty about these values. The objective of the paper is precisely to present policy recommendations that would be more robust to this uncertainty. In order to do so, we later study sets of alternative parameterizations that differ from the benchmark calibration, implying differences in either the level of debt intolerance or the government's eagerness to borrow.

Table 1 presents the benchmark calibration. A period in the model refers to a quarter. We estimated equation (6) 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.

The risk-free rate is 1 percent, which is standard in the literature. The recovery rate of debt

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.

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 (in the simulations, the government chooses to exit default every time it has the opportunity of doing so). The probability with which a government can exit 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 $\bar{q}$. 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).[12]

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 that $\phi(z)/e^z$ 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.[13] As Hatchondo et al. (2010), we solve the model numerically using value function iteration and interpolation.[14]

Table 2 shows that the model without a fiscal rule approximates moments in the data well.

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

[13]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.

[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.

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.

5 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 find that the optimal debt-brake threshold is 52.5 percent of mean annual output. The optimal spread-brake threshold is 0.45 percent. Table 3 shows that the preferred debt and spread brakes 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 3 illustrates how a fiscal rule creates new borrowing opportunities. On the one hand, the fiscal rule forces the government to choose lower 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

	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 optimal fiscal rules.

debt level). Overall, the lower interest rate allows the government to obtain more resources from borrowing with the rule (right panel of Figure 3).

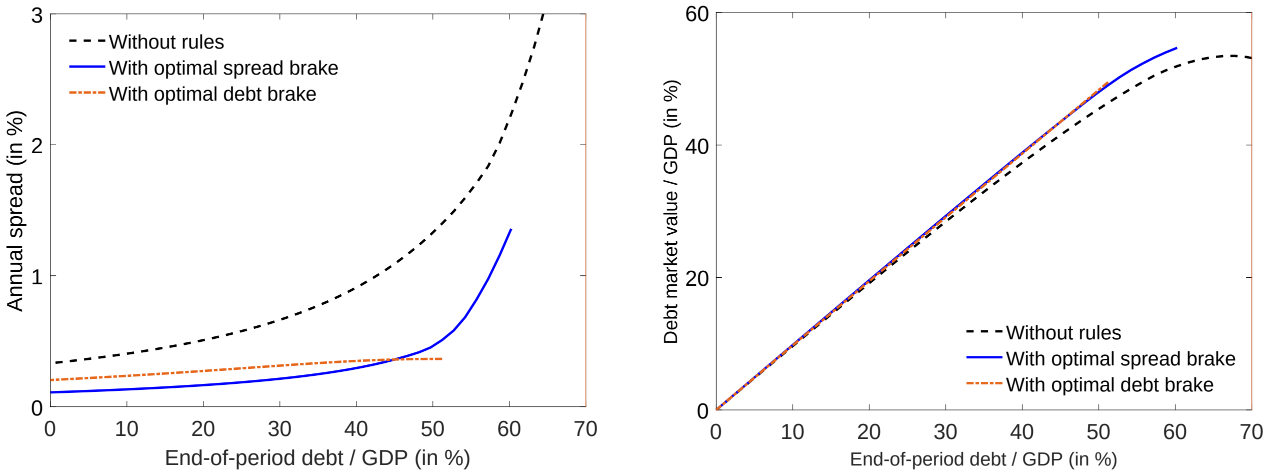

Figure 3: Borrowing opportunities. The left panel presents the annualized spread asked by lenders for different levels of debt. The right panel presents the market value of the debt stock (which represents the resources a government without debt could obtain from borrowing) for different levels of debt. The figure assumes the average TFP shock.

A common concern about spread-brake rules is that they could force fiscal policy to be too procyclical by imposing a borrowing limit that is too tight in bad times, when spreads are higher. Nevertheless, Table 3 does not present significant changes in the volatility of both public and private consumption when the optimal spread brake is imposed, indicating that this rule does not change substantially the cyclicality of fiscal policy.[15] Appendix B shows that this is also the case when we augment the model with global shocks to the lenders' risk aversion.

Why doesn't the spread brake imply a larger consumption decline after a negative shock? Figure 4 presents one of the simulation samples used for Table 3. In the benchmark simulations without a fiscal rule, the spread is first close to zero in good times, then increases with the first mild recession, and finally grows sharply and remains very high and volatile during the second deeper recession. In contrast, with the same shocks but with the optimal spread brake, the spread increases much less during the second deeper recession. 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 average annual output. By anchoring expectations about future fiscal policy, the spread brake contains the initial spread increase, which in turn contains the government's interest rate bill, allowing for a faster deleveraging without any additional sacrifice of consumption (right panel of Figure 4). It should also be noticed that concerns about spread brakes promoting procyclical fiscal policy could be mitigated by imposing brake thresholds that change over the business cycle, as many countries have done. 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 economic expansions.

Figure 4 also illustrates how nonlinearities allow the model to replicate both negligible spreads in good times and rapid increases in spreads, as observed in some fiscal crises, mostly in advanced economies.[16] Benchmark simulations are also consistent with rapid debt increases during the crisis. Note that in good times, the spread brake is not binding and debt levels are very similar with and without this fiscal rule. Nevertheless, the spread brake is still useful for containing the rapid increase in the levels of both debt and spreads triggered by adverse shocks. It should also be noticed that while in the model crises are triggered by TFP shocks, similar dynamics could be obtained augmenting the model with other shocks including, for example, contingent liability shocks that represent rescues to the banking sector (note that in practice the spread brake does

[15]It should be noted that because of the selection of no-default samples in Table 3, the comparisson across economies is not perfect.

[16]Previous working paper versions present calibrations targeting data from Argentina for which spreads are always significant in the simulations, consistently with the data for most emerging economies.

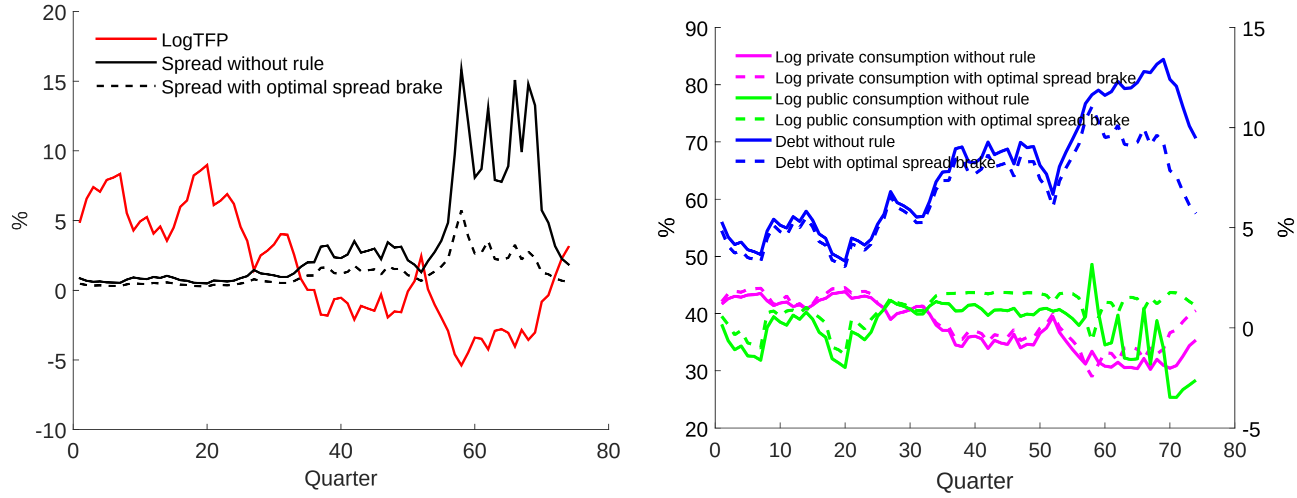

Figure 4: Simulations with and without the optimal spread brake. The level of debt is expressed as a percentage of current annual aggregate income. Consumption (right-hand-side axis) is normalized by the average level of consumption in the simulations without a fiscal rule.

not need to preclude banking rescues since, as existing debt brakes they could limit only specific expenditure items including wages, other current expenditures, or public investment).

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). We do not want to focus on the difference between debt and spread brakes that arise because of the state-contingency of spreads because as mentioned before this difference could be corrected with state contingent thresholds. Instead we next emphasize the advantages of a spread brake as a common fiscal rule for several economies and as a robust fiscal rule when there is uncertainty about the level of debt intolerance in an economy.

6 Common and robust fiscal rules

In this section we find the optimal common fiscal rule that maximizes average welfare for sets of heterogeneous economies. Economies in each set differ only in the value of one parameter. All other parameter values are the ones in the benchmark calibration. Average welfare is calculated giving the same weight to all economies in the set.

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. First, as we did with the three-period model, we study set of economies that differ in the cost of defaulting. To do so, we assume the duration of the exclusion from debt markets triggered by default is between 1 and 5 years ($\xi \in [0.05, 0.25]$). Note that since the income cost of defaulting is suffered in each period in which the government is excluded from debt markets, changing the assumed exclusion duration implies changing the income cost of defaulting (as we did with the three-period model). Second, we assume the recovery rate for debt in default is between 10 and 60 percent ($\alpha \in [0.1, 0.6]$). A higher cost of defaulting allows a government to pay a lower interest rate for any debt level. This leads the government to choose higher debt levels. A higher 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 also change the government's eagerness to borrow by assuming the discount factor $\beta \in [0.950, 0.985]$.

Overall, we study parameter values that are within the range of values commonly assumed in quantitative studies of sovereign default. Figure 5 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.

Table 4 and Figure 6 show that for sets of economies with different levels of debt intolerance, the average 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, with substantially higher minimum welfare gains.

The poorer performance of a common debt brake follows the intuition presented in Section 2. In economies with more debt intolerance, that have lower debt levels, the common debt brake is often not binding and thus have less significant effects. In fact, for the economies with the most debt intolerance, the common debt brake fails to achieve welfare gains. Furthermore, for economies with the least 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

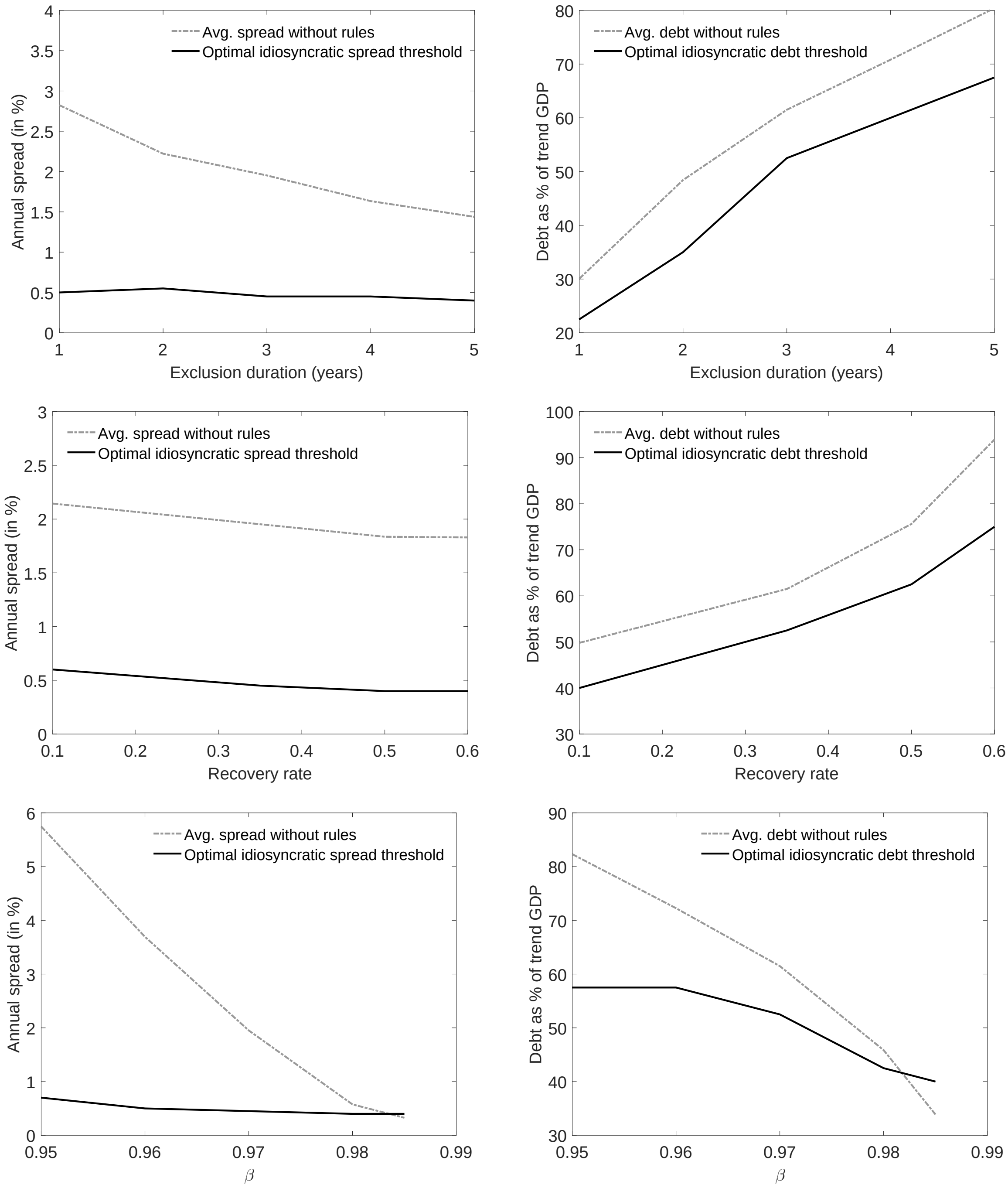

Figure 5: Average debt and spread levels and optimal idiosyncratic fiscal-rule thresholds. The exclusion duration is the average number of years a government is excluded from debt markets after defaulting.

Set of economies with different	Exclusion duration	Recovery rate	Discount factor
	Optimal common limit		
Debt-brake threshold (in %)	60.00	70.00	50.00
Spread-brake threshold (in %)	0.45	0.40	0.50
	Welfare gains with common debt brake		
Average (in %)	0.24	0.29	0.55
Maximum (in %)	0.55	0.55	1.35
Minimum (in %)	0.00	0.00	-0.01
	Welfare gains with common spread brake		
Average (in %)	0.34	0.34	0.57
Maximum (in %)	0.36	0.42	1.44
Minimum (in %)	0.28	0.20	0.04

Table 4: Welfare gains from common fiscal rules.

economies with the least debt intolerance in the top left panel of Figure 6. 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 6 also show that across economies in which governments differ in their eagerness to borrow, the difference between welfare gains obtained with a common debt or spread brake is small. This is consistent with the result presented in Proposition 6. In contrast with Proposition 6, here welfare gains are not exactly the same with the optimal common debt and spread brakes. This occurs because part of the cost of defaulting is realized in the future and, therefore, the government's discount factor affects the cost of defaulting and thus the level of debt intolerance.

Figure 5 also illustrates 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 5) even though the average spread observed without a rule in these economies

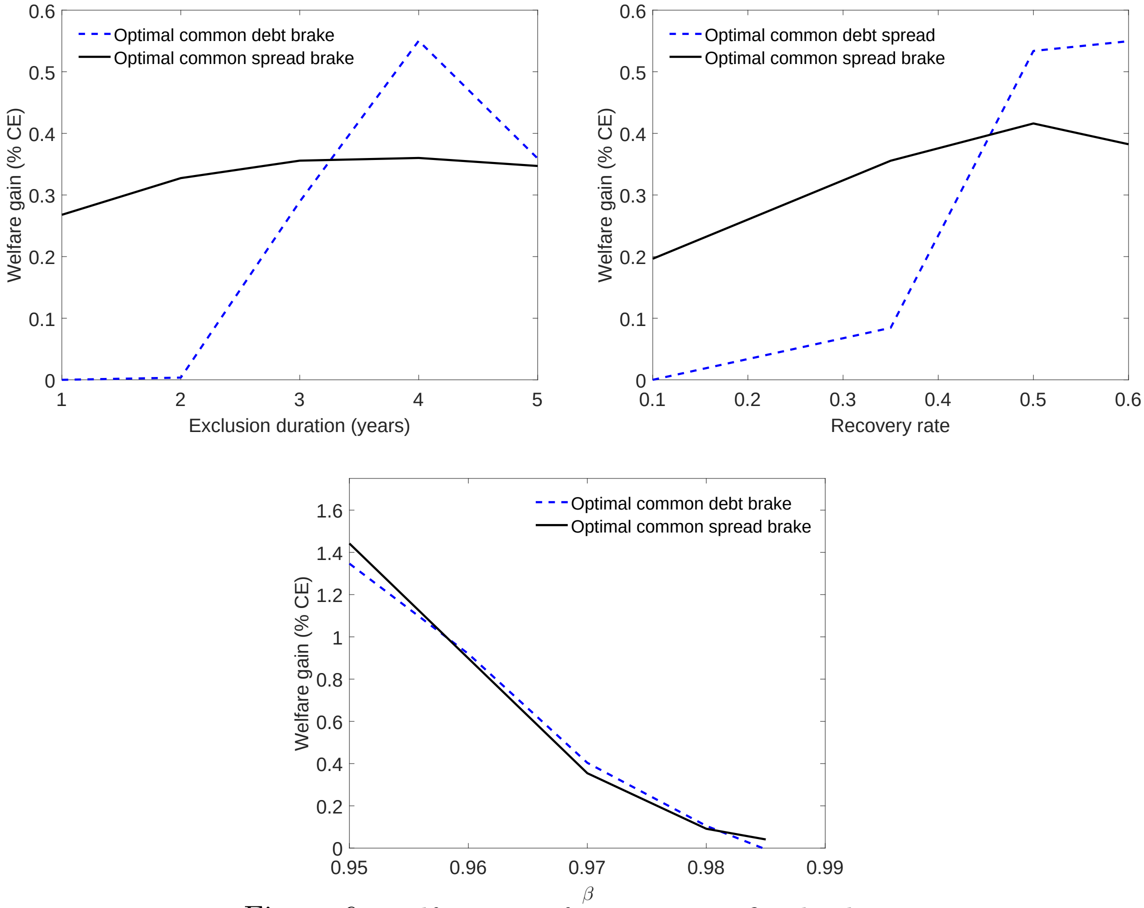

Figure 6: Welfare gains from common fiscal rules.

displays a significantly wider variation: from 0.5 to 5.8 percent. In contrast, Figure 5 shows that the optimal idiosyncratic debt-brake threshold ranges 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).

7 A Rawlsian rule setter

This section focuses on fiscal rules chosen by a Rawlsian rule setter that maximizes the welfare of the economy that is less well off after the rule is imposed. In contrast, previous sections focus on rules that maximize average welfare. As illustrated in Figure 6, maximizing average welfare may lead to optimal common debt brakes that fail to generate welfare gains in economies with higher levels of debt intolerance, which have lower levels of welfare to start with. This section focuses instead on rules that assign more weight to those economies.

There are three important motivations for the approach followed in this section. First, policymakers choosing fiscal rule without knowing some characteristics of the economy may be more concerned about the worst possible scenario. Second, policymakers choosing common fiscal thresholds for a union of heterogeneous economies may be more concerned about welfare in the more disadvantaged economies in the union (equivalently, under moral hazard, policymakers may be concerned about lowering default risk in the riskiest economies in the union). Third, the rules studied in this section can also be interpreted as robust to model misspecification when the rule setter does not know the value of a parameter of the model nor the distribution of possible values of this parameter (see Hansen and Sargent, 2008).[17]

We consider the sets of economies with different levels of debt intolerance (as given by the duration of exclusion from debt markets after defaulting and the recovery rate) studied in Section 6. We find that for the sets of economies with different exclusion durations or recovery rates, the Rawlsian debt thresholds are 23 and 40 percent, respectively. These thresholds are much lower than the ones obtained maximizing average welfare (60 and 70 percent, respectively), indicating that optimal common debt thresholds are very sensitive to the objective of policymakers. In contrast, both optimal common spread thresholds (0.5 and 0.6, respectively) and the welfare gains they generate across economies (presented in Figures 6 and 7) remain almost identical when we change the objective of the rule setter.

Figure 7 illustrates again the poor performance of a common debt brake. In order to generate welfare gains in high debt intolerance economies, the common debt threshold needs to be low. But this low debt threshold imposes unnecessarily tight borrowing constraints and thus generates substantial welfare losses in economies suffering less debt intolerance. That is, in order to generate welfare gains in high debt intolerance scenarios, policymakers choosing robust debt thresholds under uncertainty may impose large welfare losses in low debt intolerance scenarios. Similarly, in order to generate welfare gains in higher debt intolerance economies in a union (e.g., maybe Greece or Portugal), policymakers choosing common debt thresholds may impose large welfare

[17]Note that in the sets of economies that we study, the economy suffering the most debt intolerance has lower welfare both before and after fiscal rules are introduced.

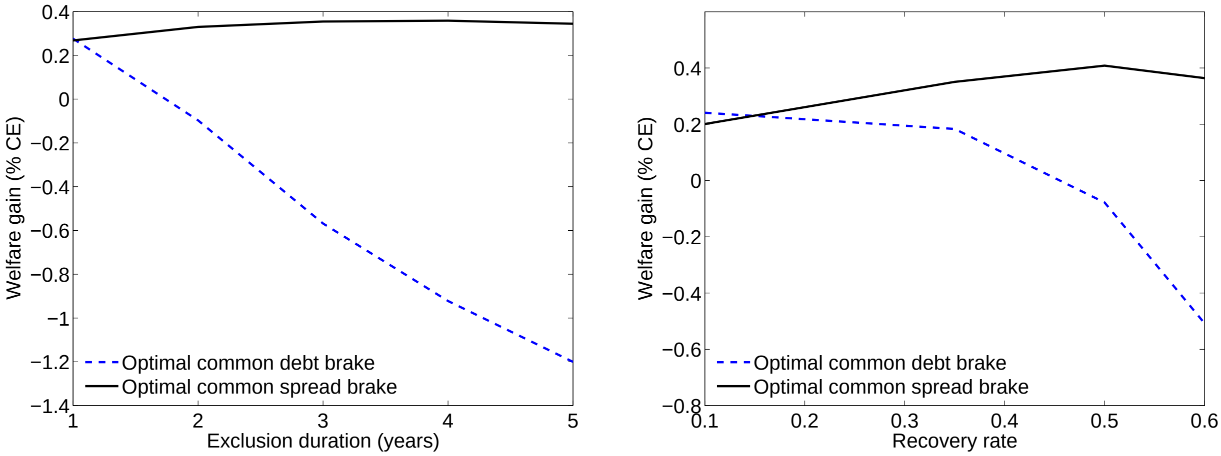

Figure 7: Welfare gains from Rawlsian fiscal rules.

losses in lower debt intolerance economies (e.g., maybe Germany or even Italy). Thus, while the results in Section 5 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 a debt brake as the fiscal rule for an economy with uncertainty about the level of debt intolerance, or as a common rule for a union of heterogeneous economies.

8 Commitment to the optimal fiscal rule

In this section, we first explain that imposing a relatively small cost of deviating from either the optimal idiosyncratic debt or spread brake would be enough for preventing governments from doing so. Second, we show that the cost necessary for preventing deviations from a common debt brake could be high, and much higher than the cost of preventing deviations from a common spread brake.[18] Third, we discuss how countries are improving their commitment to fiscal rules.

8.1 Commitment to the optimal idiosyncratic fiscal rule

We next show that the commitment required to implement the optimal idiosyncratic fiscal rules for the benchmark economy (i.e., either a 52.5 percent debt threshold or a 0.45 percent spread

[18]Appendix C shows that the cost of preventing deviations from a no-default rule are high, even when we consider an idiosyncratic rule.

threshold) is relatively small. Thus, if we extended the model allowing the government to abandon the fiscal rule but assumed a relatively small cost of doing so, the government would never abandon the optimal rule (as we assume throughout the paper).

The intuition for why the government would not abandon the optimal rule if there is a small cost of doing so is straightforward. One could imagine that a government may want to abandon a fiscal rule to borrow more. However, as illustrated in Figure 3, the fiscal rule improves the government's borrowing opportunities, allowing it to borrow more. Thus, in general, the government prefers to face the borrowing opportunities allowed by the fiscal rule. Note also that as illustrated in Figure 4, improvements in borrowing opportunities generated by fiscal rules may be particularly important in bad times.

We next find the cost that would prevent the government from surprising lenders and abandoning the rule for one period and returning to the rule after that. We find that this cost would also prevent the government from abandoning the rule if it has to wait longer to return to it. This occurs because abandoning the fiscal rule for only one period does not deteriorate the government's borrowing opportunities (as abandoning the rule for more periods would).

Since abandoning a fiscal rule for one period after defaulting makes no difference (because the government cannot borrow in the default period), we focus on cases in which the government repays its debt. In these cases, the expected lifetime utility of a government that abandons its fiscal rule for one period is given by

$$\hat{V}^R(b,z,x) = \max_{b'\geq 0, g\geq 0, \tau\geq 0} \left\{ u\left(c,g,1-l\right) + \beta \mathbb{E}_{z'|z} V^{Rule}(b',z') \right\}, \tag{13}$$

subject to

$$l = \hat{l}\left(log(x)+z,\tau,g\right),$$

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

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

$$q^{Rule}\left(b',z\right) \geq \underline{q} \text{ if } b' > b, \tag{14}$$

where the value for $\underline{q}$ is the one in the benchmark economy (without rules), the superscript *Rule* is used to denote equilibrium functions in the economy with the optimal fiscal rule, and

x denotes a TFP loss in the period in which the government abandons the rule. We use x to measure the cost of abandoning the rule. For each combination of debt and TFP realizations in the simulations of the economies with the optimal fiscal rules presented in Table 3, we find the one-time TFP loss that would be needed to deter a deviation from the optimal rule. Formally, for each pair (b, z), we find the value x^* that solves $\hat{V}^R(b, z, x^*) = V^{R,Rule}(b, z)$. We measure the cost needed to deter a deviation form the rule as the difference between the equilibrium output that would be observed when the government complies with the rule and the equilibrium output that would be observed after a deviation from the rule with the TFP loss x^*. We express this output loss in the deviation period as a percent of the annual mean output level in the economy with the optimal fiscal rule.

We find that across all combinations of (b, z) in the simulations of the economies with the optimal fiscal rules, if the cost of deviating from the optimal debt brake is at least 0.7 of mean annual output, or the cost of deviating from the optimal spread brake is at least 1.1 percent of mean annual output, the government would choose to not deviate from these rules (even if it could return to the rule after one period). Furthermore, the median cost needed to prevent deviations from the optimal brakes is zero. Again, this indicates that assuming a relative small cost of abandoning the fiscal rule would be enough to prevent the government from doing so.

It should be emphasized that the enforcement costs described in the previous paragraph should not be compared with the welfare gains presented in Table 3. Those welfare gains are for an initial state with zero debt and the unconditional mean level of TFP. The enforcement costs presented in the previous paragraph are the maximum across the ergodic set of states in the simulations, and correspond to the case in which commitment to the rule is most difficult (because the government can return to the rule after one quarter). If we assume instead that abandoning the optimal fiscal rule would imply that the government can never adopt a fiscal rule again, there is no state of the economy (i.e., no combination of b and z) for which the government would want to abandon this rule. This is true even if we assume that the equilibrium bond price schedule (and thus, the government's borrowing opportunities) does not change in the period in which the government deviates from the rule (after that, the government faces the benchmark less favorable borrowing constraints illustrated in Figure 3). This indicates that if the government loses its ability to commit to a rule after one deviation, the optimal rules are self-enforcing. In this case, deviating from the rule triggers welfare losses equivalent to one-time output drops of at least 2.7 and 1.6 percent of mean annual output under for optimal debt and spread brake, respectively.

8.2 Commitment to the optimal common and robust fiscal rule

The previous subsection shows that the cost necessary for preventing deviations from the optimal idiosyncratic debt or spread brake is relatively small. In contrast, this subsection shows that the cost necessary for preventing deviations from a common debt brake could be high, and much higher than the cost of preventing deviations from a common spread brake. We consider the optimal Rawlsian rules for economies with different exclusion durations presented in Section 7 (with a 23 percent debt threshold or a 0.5 percent spread threshold).

Figure 8 illustrates how committing to a debt brake may be difficult. As before, we find the penalty needed to prevent the government from abandoning a fiscal rule. We focus on the case in which after abandoning the rule, the government can never implement another one. Recall that the penalty needed to prevent the government from abandoning a rule is smaller when we assume the government can never implement a new rule after abandoning the existing rule. In fact, in this case, no penalty would be needed to prevent the government abandons the optimal idiosyncratic rules studied in the previous subsection. Consistently, Figure 8 shows that no penalty would be needed to prevent the government abandons the Rawlsian rules in the high debt intolerance economies that Rawlsian rules prioritize.

Nevertheless, Figure 8 also shows that even in this case the rule can only be abandoned forever and thus commitment to the rule is easier, the penalty needed to enforce the Rawlsian debt brake across economies is very large, reaching 23.4 percent of average annual output for the lowest debt intolerance case. This indicates that if there is uncertainty about the characteristics of the economy or these characteristics can change over time, there are set of characteristics for which the penalty needed to prevent the government from abandoning the Rawlsian debt brake would be very large and, therefore, this debt brake is not credible. Similarly, in a union of heterogeneous economies, those suffering less debt intolerance may have strong incentives to

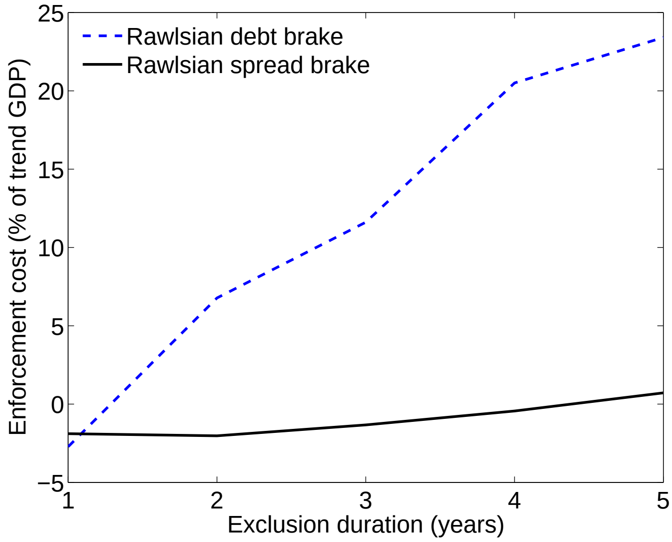

Figure 8: Penalty needed to prevent the government from abandoning the common Rawlsian rule.

abandon the common Rawlsian debt brake needed to reduce fiscal risk in economies suffering more debt intolerance. This in turn could weaken the credibility of the debt brake in all the economies in the union. This is consistent with the commonly held view of Germany and France (low debt intolerance economies) playing an important role in weakening the Stability and Growth Pact before the European crisis, which in turn contributed to the crisis (Baerg and Hallerberg, 2016). In contrast, the penalty necessary for enforcing the common Rawlsian spread brake is small (and often negative) across economies, with a maximum penalty of 0.7 percent of average annual output for the lowest debt intolerance economy.

8.3 How countries are improving their commitment to fiscal rules

Countries continue strengthening 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 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, debt brakes in Germany, Switzerland, and Slovakia, and other automatic correction mechanisms such as "sequestration" processes).

Countries also continue to enhance the legal status of fiscal rules.[19] Moreover, supranational authorities can help enforce supranational rules. In addition, fiscal rules based on market discipline (as advocated in this paper) could be less susceptible to accounting manipulations, facilitating commitment. Governments have also issued bonds with floating rates based on the market yield of other government debt in an attempt to show their commitment to low fiscal risk (e.g., Argentina in 1998, the U.S. during World War 1, and Italy in the 1980s).

Empirical studies find that well-designed fiscal rules improve fiscal outcomes, indicating some commitment to these rules (Corbacho and Schwartz, 2007; Debrun and Kumar, 2007; Debrun et al., 2008; Deroose et al., 2006; EC, 2006; Kopits, 2004).[20] Heinemann et al. (2014), Iara and Wolff (2011), and Thornton and Vasilakis (2017) find that fiscal rules reduce the sovereign premium. 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. This section argues that it could be easier to commit to spread rules than to commit to existing debt rules.

9 Conclusions

It is often recognized that discussions of fiscal policy lack an anchor to improve commitment about future policies (Leeper, 2010). These discussion also ignore possible advantages of using (debt) prices instead of (debt) quantities as planning instruments (Weitzman, 1974), and the need for policies that are robust to model misspecification (Hansen and Sargent, 2008). 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.

[19]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.

[20]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.

We use a sovereign default model to search for a common fiscal rule that maximizes 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 be a more robust fiscal anchor than a debt brake.

Furthermore, uncertainty may make it difficult to commit to a debt brake and, similarly, it may be difficult to generate ownership of a common debt brake in a union of heterogeneous economies. In contrast, commitment to a common and robust spread brake that allows economies suffering less debt intolerance to borrow more would be easier.

We see advantages of market determined fiscal rule targets over debt targets even beyond the ones discussed 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? Should the spread brake trigger fiscal adjustment only during expansions? When the spread is above the brake threshold, how fast should the fiscal adjustment be? Which maturity should be used for the spread brake? 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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Appendix to “Fiscal Rules and the Sovereign Default Premium”

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A Proofs of propositions

A.1 Proof of Proposition 1

Ramsey policies satisfy

$$u'\left(c_1(b_1^R,b_2^R)\right)=\beta u'\left(c_2(b_1^R,b_2^R)\right)=\frac{\beta^2\mathbb{E}\left[u'\left(c_3(b_1^R,b_2^R,y_3\right)\left[1-\hat{d}(b_1^R,b_2^R,y_3)\right]\right]}{q_2(b_1^R,b_2^R)+b_2^R\frac{\partial q_2(b_1^R,b_2^R)}{\partial b_2}}.$$

For any b_1, the period 2 Markov strategy satisfies

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

Thus, if $b_1^M=b_1^R$, $b_2^M(b_1^M)=b_2^R$. Since Ramsey policies maximize the government's expected utility in period 1, they are the Markov policies (and there is no room for improving welfare with fiscal rules).

A.2 Proof of Proposition 2

Ramsey policies satisfy

$$\begin{aligned} u'\left(c_1(b_1^R,b_2^R)\right)\left[q_1(b_1^R,b_2^R)+b_1^R\frac{\partial q_1(b_1^R,b_2^R)}{\partial b_1}\right] &= \beta u'\left(c_2(b_1^R,b_2^R)\right)\left[\delta-b_2^R\frac{\partial q_2(b_1^R,b_2^R)}{\partial b_1}\right] \\ &\quad +\beta^2(1-\delta)\mathbb{E}\left[u'\left(c_3(b_1^R,b_2^R,y_3)\right)\left[1-\hat{d}(b_1^R,b_2^R,y_3)\right]\right], \end{aligned} \tag{1}$$

$$\beta u'\left(c_2(b_1^R,b_2^R)\right)\left[q_2(b_1^R,b_2^R)+b_2^R\frac{\partial q_2(b_1^R,b_2^R)}{\partial b_2}\right] = \beta^2\mathbb{E}\left[u'\left(c_3(b_1^R,b_2^R,y_3)\right)\left[1-\hat{d}(b_1^R,b_2^R,y_3)\right]\right] - \mathbf{u}'\left(\mathbf{c_1}(\mathbf{b_1^R},\mathbf{b_2^R})\right)\mathbf{b_1^R}\frac{\partial \mathbf{q_1}(\mathbf{b_1^R},\mathbf{b_2^R})}{\partial \mathbf{b_2}}. \tag{2}$$

For any b_1, the period 2 Markov strategy satisfies

$$u'\left(c_2(b_1,b_2^M(b_1))\right)\left[q_2(b_1,b_2^M(b_1))+b_2^M(b_1)\frac{\partial q_2(b_1,b_2^M(b_1))}{\partial b_2}\right] = \beta\mathbb{E}\left[u'\left(c_3(b_1,b_2^M(b_1),y_3)\right)\left[1-\hat{d}(b_1,b_2^M(b_1),y_3)\right]\right]. \tag{3}$$

The second term in the right hand side of equation (2) represents the marginal cost that borrowing in period 2 imposes on consumption in period 1. Note that this term is positive (the marginal utility of period 1 consumption is positive, the period 1 bond price in decreasing in period 2 borrowing, and because period 1 income equals zero and the government is impatient, period 1 borrowing is positive). 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 3). Therefore, Markov policies are different from Ramsey policies (if $b_1^M = b_1^R$, $b_2^M(b_1^M) \neq b_2^R$).

A.3 Proof of Proposition 3

Since $f(y_3) \geq 0$ for all $y_3 \geq 0$, q_2 is a strictly decreasing function of b_2. Therefore, if the period 1 government chooses b_1^R, imposing the spread brake threshold $\underline{q}^* = q_2(b_1^R, b_2^R)$ is equivalent to imposing the debt brake threshold $\bar{b}^* = (1-\delta)b_1^R + b_2^R$. Since

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

with either a debt brake with threshold $\bar{b}^* = (1-\delta)b_1^R + b_2^R$ or a spread brake with threshold $\underline{q}^* = q_2(b_1^R, b_2^R)$, if $b_1^M = b_1^R$, $b_2^M(b_1^M) = b_2^R$, and Markov policies coincide with Ramsey policies.

A.4 Proof of Proposition 4

Note first that because $u(c) = c$ and $\beta < 1$, the government's expected utility in period 1 is maximized with period-2 consumption equal to zero (period-1 consumption is more valuable than period-2 consumption and without default risk in period 2, borrowing in period 1 is as costly as borrowing in period 2). Therefore, Ramsey policies are given by $\{b_1^R, 0\}$, where b_1^R satisfies

$$1 - \frac{b_1^R}{\phi} \frac{f\left(\frac{b_1^R}{\phi}\right)}{1 - F\left(\frac{b_1^R}{\phi}\right)} = \beta^2. \tag{4}$$

Assumption 1 guarantees that there is a unique level of $\frac{b_1^R}{\phi}$ that solves equation (4). Let η denote this level. Then, for any economy with cost of defaulting ϕ, $b_1^R = \eta\phi$.

A.5 Proof of Proposition 6

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.

B Global factors and spread brakes

This appendix 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., 2013; 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 ($p_H > 0$). This model of the discount factor has often been used in models of sovereign default (e.g., 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 1). All other parameter values are the ones used for the benchmark without risk premium.

Table 1 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 with plausible spread levels, a model with risk premium features a lower default frequency.

Table 1 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.[1] Therefore, the constraint imposed by the spread

[1]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 1: Simulations with shocks to the lenders' risk aversion. We measure welfare gains assuming $p = 0$.

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 2 and Figure 1 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 lenders, Figure 2 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 ranges only from 0.6 to 1.2 percent.

B.1 Options to mitigate concerns about exogenous spread volatility

Concerns about the effects of exogenous spread volatility in a country with a spread brake could be mitigated by targeting a "core" or "long-term" measure of the spread that is not affected

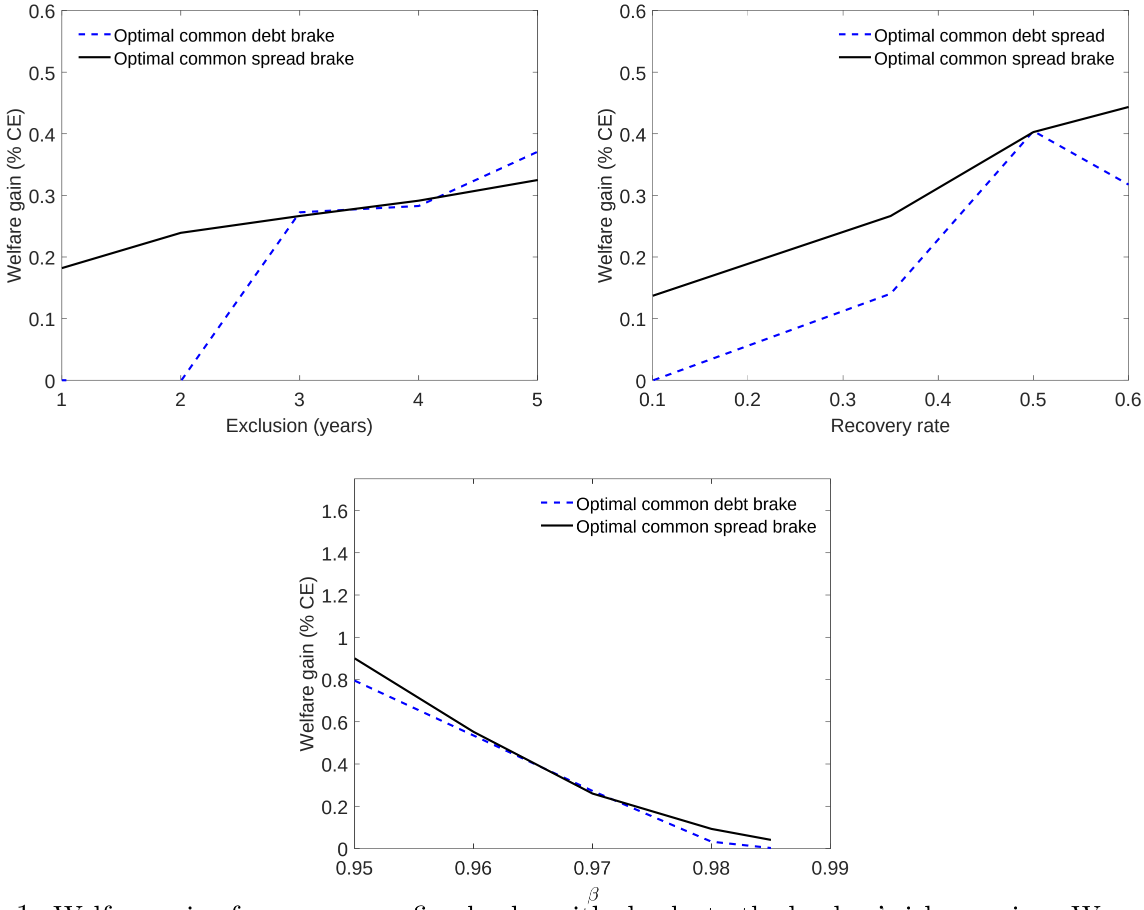

Figure 1: Welfare gains from common fiscal rules with shocks to the lenders' risk aversion. We measure welfare gains assuming $p = 0$.

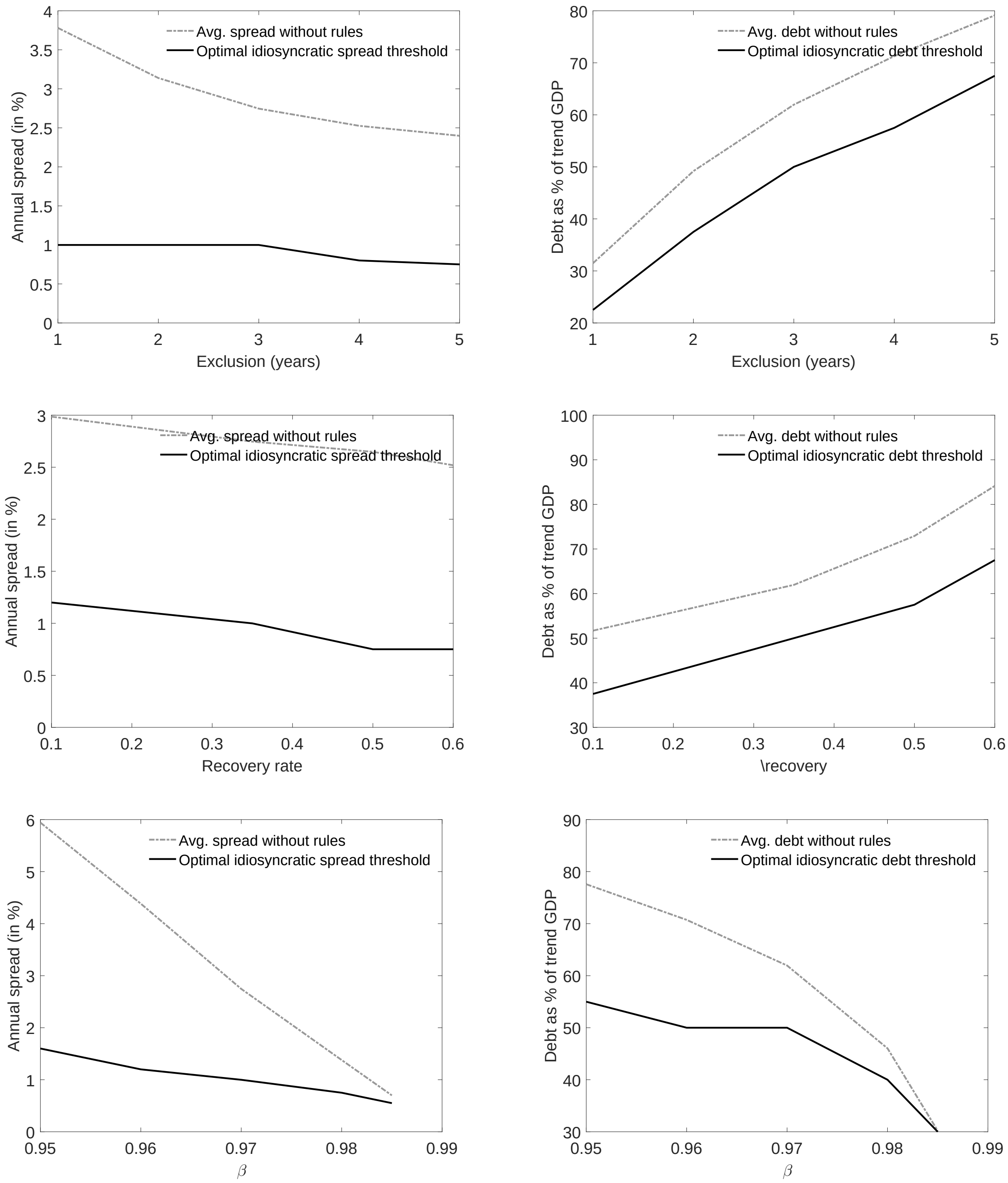

Figure 2: Average debt and spread levels and optimal rule thresholds in different economies with shocks to the lenders' risk aversion.

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 2: Welfare gains from common fiscal rules with shocks to the lenders' risk aversion. We measure welfare gains assuming $p = 0$.

by this volatility.[2] This could be done by comparing the price of sovereign debt with the price of other assets (including the price of debt issued by other countries) also affected by the same factors. 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 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

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

fiscal rule. Such councils could be in charge of computing "core" or "long-term" measures of the spread.

In addition, a spread brake would not require the government to react to high-frequency changes in sovereign spreads. For instance, once a year, when the budget is prepared, the spread brake could impose a limit to the fiscal balance when the average spread over previous fiscal years was above the spread threshold.

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.[3]

C Commitment to a no-default rule

We next discuss a rule that would force the government to pay its debt, eliminating 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 enforcing a rule that eliminates the possibility of default would require large penalties for deviating from this rule. This is consistent with the rarity of fiscal rules intending to eliminate the possibility of defaulting. In addition, this is in contrast with the small cost of deviating from the rule required to enforce optimal spread brakes (Section 8).

In order to study the economy with the no-default fiscal rule, we introduce an exogenous borrowing limit. Recall that in the model with default, borrowing is endogenously limited by the possibility of default. 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

[3]Bova et al. (2016) present a dataset with the fiscal cost of contingent liabilities and their effect on debt levels. Contingent liabilities are a standard component of the IMF debt sustainability analysis (IMF, 2013).

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:

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

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 (recall that in this case, both the optimal idiosyncratic debt and spread brakes are self-enforcing, as the government would not want to abandon these rules).

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. The mean debt level in the simulations 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 wider 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.

As in Section 8, we first find the value of abandoning the fiscal rule for any implied one-time

TFP loss x,

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

subject to

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

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

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

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 (i.e., x^* such that $W(b, z) = \hat{V}^D(\hat{\alpha}b, z, x^*)$).

We find that the penalty for abandoning the no-default rule needed to prevent the government from doing so in all states of the economy is 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 cost needed across states is between 11.5 and 11.6 percent.

The difficulties of enforcing a no-default fiscal rule are 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.

D Political myopia

Political myopia arising because of political polarization or political turnover, is often mentioned as a justification for fiscal rules (the importance of political myopia is highlighted by Amador, 2012; Azzimonti, 2011; Azzimonti et al., 2016; Cole et al., 1995; Cuadra and Sapriza, 2008; Halac and Yared, 2014, 2015; and Hatchondo et al., 2009). The paper shows that fiscal rules can be beneficial even in the absence of political myopia. This appendix shows that assuming political myopia implies tighter 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. The relative performance of the common spread brake improves as we incorporate the positive correlation between political myopia and debt intolerance observed in the data (countries with more political myopia pay higher spreads for lower debt levels).

To gauge the role of political myopia, suppose in every economy consumers discount future utility flows with a factor $\beta^C = 0.99$. The degree of political myopia is then given by the difference between the consumers' discount factor β^C and the discount factor used by the government when making decisions, β. We search for the optimal common rule for a set of economies with different degrees of political myopia: $\beta \sim U[0.950, 0.985]$. We assume fiscal rules are chosen maximizing welfare while discounting future utility flows with β^C. 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 tighter. Note that the set of government's discount factors studied in this appendix ($\beta \sim U[0.950, 0.985]$) is the same set we study in Section 6. The only difference is that in this appendix, variations in the government's discount factor represent variations in political myopia, and we evaluate welfare using $\beta^C = 0.99$ for all the economies in the set (in contrast, in Section 6 we evaluate welfare in each economy using the discount factor of the government for that economy). Figure 3 presents the optimal idiosyncratic rule thresholds for economies with different degrees of political myopia. Comparing these thresholds with the ones presented in Section 6 shows that political myopia imply lower optimal rule thresholds. Furthermore, 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 6 for the set of economies with different discount factors (50 and 0.5 percent, respectively).

The top left panel of Figure 3 also shows that there is little variation in the optimal idiosyncratic spread-brake threshold for economies with different political myopia (optimal thresholds

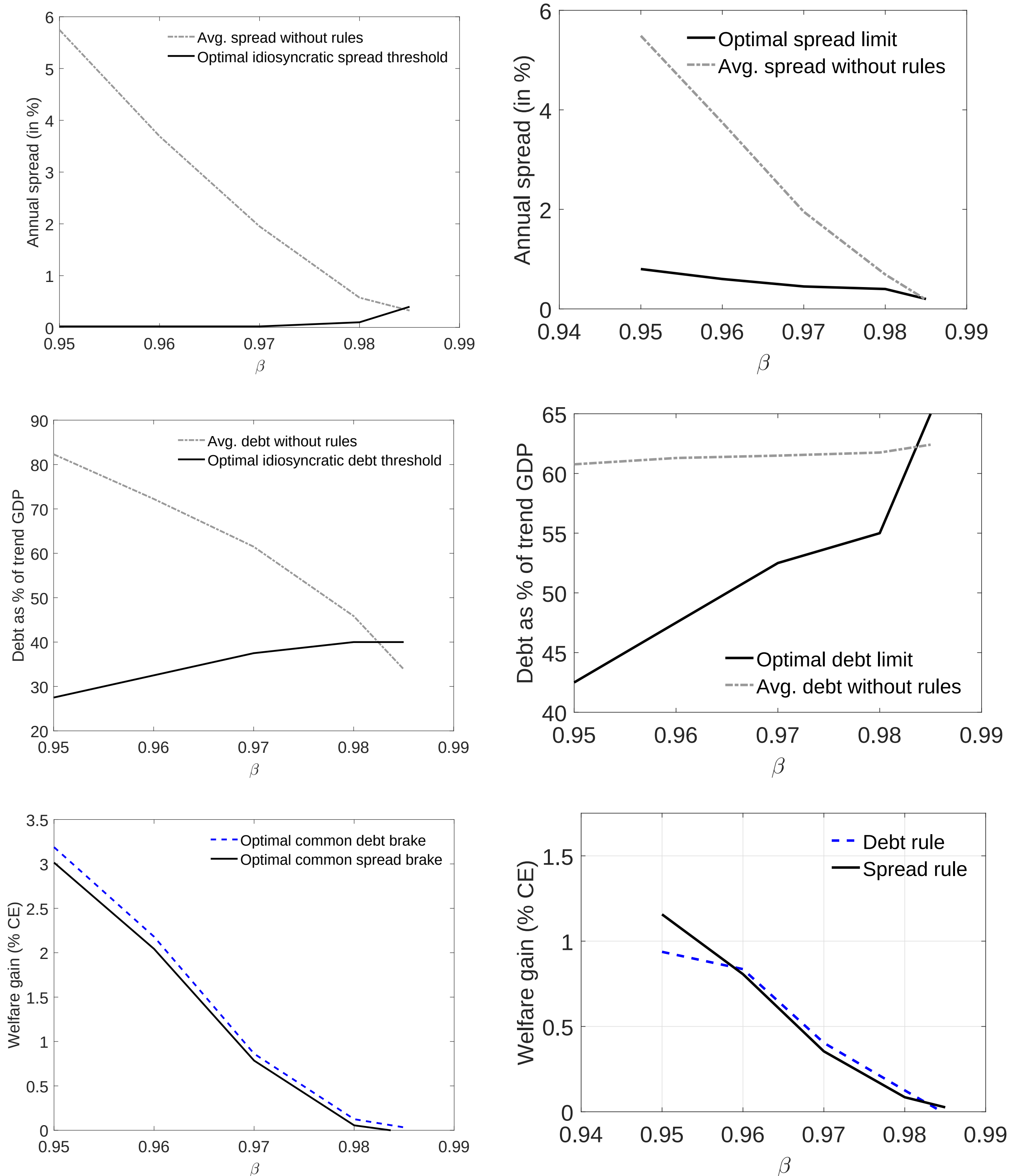

Figure 3: Average debt and spread levels, optimal idiosyncratic rule thresholds, and welfare gains in economies with different degrees of political myopia. The left panels correspond to economies that only differ in the level of political myopia. The left panels correspond to economies that also differ in the level of debt intolerance.

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 spread-brake thresholds that result from this framework.

Comparing the welfare gains presented in Figure 3 with the ones presented in Section 6 shows that, as expected, fiscal rules generate larger welfare gains when they also mitigate the effects of political myopia. In addition, the bottom left panel of Figure 3 shows that changes in welfare gains across economies with different degrees of political myopia are similar with either a common debt or spread brake.[4] This is consistent with the results presented in Sections 2 and 6 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 on the mapping from debt to spreads.

It should be noted, however, that countries with more severe political frictions often pay a higher spread for lower debt levels. This is illustrated in Figure 4. This indicates that countries with more severe political frictions typically suffer a more severe problem of debt intolerance. In contrast, the middle left panel of Figure 3 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 paper would arise. To illustrate this point, the right panels of Figure 3 present results for a set of economies with the same differences in political myopia presented in the left panels, but in which the duration of the exclusion from debt markets triggered by a default is changed to generate similar debt levels across economies without a fiscal rule (middle right panel of Figure 3). Thus, economies with more political myopia have a lower cost of defaulting and, therefore, suffer more debt intolerance (pay a much higher spread for similar debt levels). Note that we are still underrepresenting the correlation of political myopia and intolerance in the data, where countries with more myopia have substantially lower debt levels (Figure 4). Nevertheless, the middle right panel of Figure 3

[4] As in the benchmark, welfare gains in the bottom left panel of Figure 3 are slightly higher with the debt brake than with the spread brake because of the state contingency of spreads. These differences could be corrected with state-contingent fiscal rule thresholds.

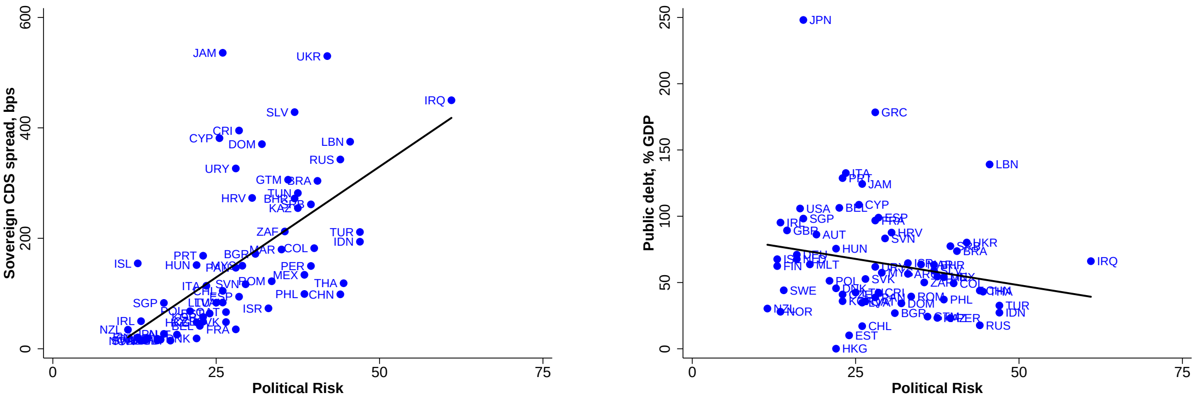

Figure 4: Political risk and debt intolerance. The Figure presents average levels of CDS spreads and political risk in 2015, for all countries with CDS spread data (DataStream). Political risk equals 100 minus the Political Risk Rating of the International Country Risk Guide (that takes values from 0 to 100, with a higher value indicating more risk). Debt levels are from the April 2016 IMF World Economic Outlook.

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shows that incorporating the correlation between myopia and intolerance generates very different optimal debt thresholds across economies. In contrast, optimal spread thresholds continue to be similar across economies. The bottom right panel of Figure 3 shows that, the optimal common debt threshold (50 percent) generates significant welfare gains across economies. The common debt threshold is particularly effective in this example because we assume (in contrast with the data) that without a rule, debt levels are as high in high debt intolerance economies as they are in low debt intolerance economies. Therefore, the common threshold is binding in all economies. However, the bottom right panel of Figure 3 also shows that for economies with the lowest level of debt intolerance, the optimal common spread threshold (0.55 percent) generates larger welfare gains than the optimal common debt threshold.

E 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 may reduce the volatility of consumption but 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:

$$\bar{b}(z) = \bar{y}[a_0 + a_1(e^z - e^{\mu_z})], \tag{5}$$

where $\bar{y}$ is the average output level in the simulations of the benchmark economy.[5] We search for the optimal value of the coefficients a_0 and a_1.

We find that the optimal debt-brake threshold does not change over the business cycle. This is, the optimal threshold is the one discussed in Section 5, which corresponds to $a_0 = 2.1$ and $a_1 = 0$. Table 3 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. Allowing for a lower brake threshold during downturns ($a_1 = 1$) has the opposite effects, i.e., it reduces the default frequency at the expense of increasing the consumption volatility.

Cuadra et al. (2010) show that in the presence of default risk, it may be optimal for a government to sequentially choose a pro-cyclical fiscal policy. This appendix 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.

[5] 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 3: Simulation with a state-contingent debt threshold $\bar{b}(z) = \bar{y}[a_0 + a_1(e^z - e^{\mu_z})]$, for $a_0 = 2.1$.

F Optimal rules for indebted governments

This appendix discusses the introduction of a debt brake in states with positive debt. We assume that when the government introduces the debt brake it announces both the debt threshold $\bar{b}$ and the length of the transition period during which the rule would not be enforced, T. The government's maximization problem is not recursive before 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

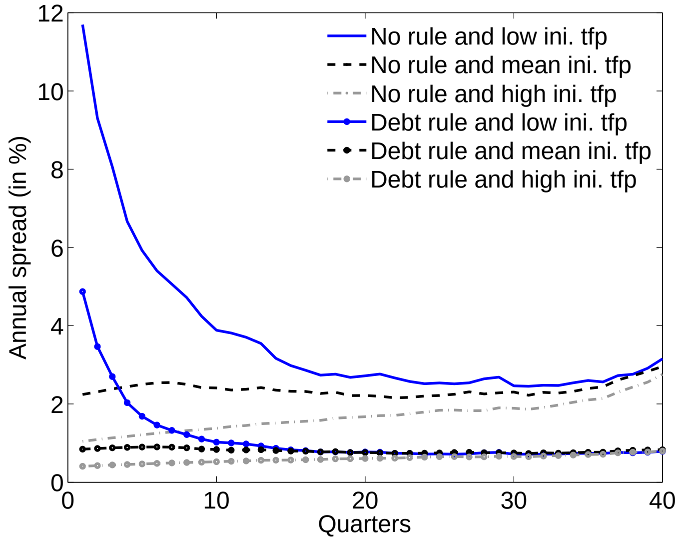

Figure 5: Spread during transitions that follow the announcement of the optimal debt brake, for samples without defaults.

the debt brake are between 0.6 and 0.8 percent, depending on the initial level of TFP.

Figure 5 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), the rule increases the cost of defaulting, allowing the government to borrow more (for a given interest rate).

Figure 5 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).

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