Working Paper Series

Improving Sovereign Debt Restructurings

WP 22-06

Maximiliano Dvorkin
Federal Reserve Bank of St. Louis

Juan M. Sánchez
Federal Reserve Bank of St. Louis

Horacio Sapriza
Federal Reserve Bank of Richmond

Emircan Yurdagul
U. Carlos III and CEPR

FEDERAL RESERVE BANK OF RICHMOND®
Richmond ▪ Baltimore ▪ Charlotte

Improving Sovereign Debt Restructurings*

Maximiliano Dvorkin
FRB of St. Louis

Juan M. Sánchez
FRB of St. Louis

Horacio Sapriza
FRB of Richmond

Emircan Yurdagul
U. Carlos III and CEPR

April 6, 2022

Abstract

The wave of sovereign defaults in the early 1980s and the string of debt crises in subsequent decades have fostered proposals involving policy interventions in sovereign debt restructurings. The global financial crisis and the recent global pandemic have further reignited this discussion among academics and policymakers. A key question about these policy proposals for debt restructurings that has proved hard to handle is how they influence the behavior of creditors and debtors. We address this challenge by evaluating policy proposals in a quantitative sovereign default model that incorporates two essential features of debt: maturity choice and debt renegotiation in default. We find, first, that a rule that tilts the distribution of creditor losses during restructurings toward holders of long-maturity bonds reduces short-term yield spreads, lowering the probability of a sovereign default by 25 percent. Second, issuing GDP-indexed bonds exclusively during restructurings also reduces the probability of default, especially of defaults in the five years following a debt restructuring. The policies lead to welfare improvements and reductions in haircuts of similar magnitude when implemented separately. When jointly implemented, they reinforce each other's welfare gains, suggesting good complementarity.

JEL Classification: F34, F41, G15

Keywords: Crises, GDP-indexed Debt, Distribution of Creditor Losses, Default, Sovereign Debt, Maturity, Restructuring, Country Risk, International Monetary Fund

*The views expressed in this paper are those of the authors and do not necessarily reflect those of the Federal Reserve Bank of St. Louis, the Federal Reserve Bank of Richmond, or the Federal Reserve System. Yurdagul gratefully acknowledges the grant IJC2018-038229-I by MCIN, grant 2020/00369/001 by AEI, grants EPUC3M11 (V PRICIT) and H2019/HUM-589 by Comunidad de Madrid.

1 Introduction

The sovereign debt crises of the last decades, including those in Latin America in the early 1980s, Russia (1997-1998), Argentina (2001-2002), Greece (2011-2012), and Ukraine (2015), among others, have encouraged the development of policy frameworks aimed at improving both the structure of sovereign debt and the resolution of sovereign debt crises. Most recently, the large increases in sovereign debt after the COVID-19 pandemic resurfaced concerns about debt sustainability. Thus, the international economic landscape has raised the need to think more about policies that may affect the debt restructuring process and outcome, and that may therefore provide tangible recommendations for dealing with debt default resolutions. The proposals (e.g., Alfaro and Kanczuk, 2006; IMF, 2017, 2020) have included the development of practices and instruments that improve incentives for borrowers and creditors to agree on a prompt, orderly and predictable restructuring of unsustainable debt, as well as lowering debt levels and lengthening debt maturity, among other measures.

The large and growing literature on quantitative sovereign default models in the tradition of Eaton and Gersovitz (1981) has advanced our understanding of the causes and consequences of default, the dynamics of emerging-market bond yields, and the issuance of debt of different maturities by developing countries. However, by and large, policy proposals to resolve sovereign debt crises are grounded on empirical analysis of previous default and restructuring episodes, or based on policymakers' and analysts' judgments, with a minimal contribution to this debate—if at all—from quantitative models of sovereign default.[1] This disconnect stems mainly from the difficulties in solving and computing rich and sophisticated models that capture many characteristics of emerging countries' default, maturity choice, and restructuring decisions. In this paper, we bridge such disconnect using a debt renegotiation framework based on Dvorkin et al. (2021) that rationalizes several stylized facts of sovereign debt restructurings and microfounds the behavior of creditors and debtors. It thus serves as a laboratory to gain insights into the role

[1] For example, the extensive discussions on sovereign debt restructurings in the recent works compiled in Guzman et al. (2016) and Abbas et al. (2019) focus on important institutional details, review the results of previous restructuring episodes, and analyze the merits of different restructuring proposals. However, none of these discussions is rooted in quantitative models of default.

of frequently-mentioned policy interventions on the behavior of economic agents and how these shape debt restructuring outcomes and sovereign debt dynamics in general.

The IMF (2002) states that, "A sovereign debt restructurings mechanism (SDR) should aim to preserve asset values and protect creditors' rights, while paving the way toward an agreement that helps the debtor return to viability and growth." We analyze two policies that are directly linked to these main reasons for conducting restructurings. Our first policy relates to asset values and creditors' rights. *We assess the impact of alternative distributions of losses across lenders holding sovereign bonds of different maturities.* One major source of uncertainty in sovereign debt restructurings is how to resolve inter-creditor equity issues.[2] One aspect of this complex issue that has proven particularly difficult to address is the treatment of claims with different residual maturities. Moreover, framing these discussions in quantitative equilibrium default models poses unique challenges. Our model allows us to overcome these challenges. The results of our analysis suggest that a rule that tilts the distribution of creditor losses during restructurings toward holders of long-maturity bonds reduces short-term yield spreads in bad times, reducing the default probability of the sovereign during periods of elevated credit market stress.

Our second policy relates to debt instruments that may help the debtor return to viability and growth. *We evaluate the use of GDP-indexed bonds during sovereign debt restructurings.* As pointed out in 2012 by the United Nations Economic and Social Council (ECOSOC), borrowers would benefit from some "breathing space" after debt restructurings. GDP-indexed debt is an instrument that has been widely discussed in policy circles as a tool for debt management and sovereign risk-reduction that could help improve the resilience of public finances to economic downturns and thus strengthen public debt sustainability. There is also broad recognition that, except for cases in which GDP-indexed bonds are introduced in the context of a debt restructuring, it would require several years of consistent issuance before the share of these bonds in total government debt became large enough to significantly enhance the resilience of public debt to adverse economic shocks (see Barbieri Hermitte, 2020). In light of these considerations, we study a policy where the country can issue GDP-indexed bonds with choice of maturity in the context

[2] See, for example, IMF (2013a).

of a debt restructuring. Our analysis suggests that using GDP-indexed bonds during distressed debt restructurings can contribute to remedying the lack of market access experienced by troubled borrowers and significantly reduce the probability of repeated restructurings. Furthermore, Consiglio and Zenios (2018) observe that the prevalent early form of GDP-contingent debt was that of GDP warrants, also known as value recovery rights, whereby additional payments were made when output growth exceeded a threshold or another favorable event occurred. Such instruments were used in several restructurings, including Mexico, Nigeria, Uruguay, Venezuela, Argentina, Greece, and Ukraine. The authors also point out that the G20 meeting in Chengdu, China, in July 2016, revived the idea of GDP-contingent debt, but focused instead on cash instruments that pay differentially both on the upside and downside, depending on growth, which they refer to as GDP-linked bonds.[3] Following this distinction in the literature, we provide a comparative analysis of the pricing and hedging implications of these two types of GDP indexation, and we find that GDP-linked bonds have more substantial effects on the recurrence of defaults than asymmetric adjustment schemes like GDP warrants.

We evaluate the welfare gains of the two central policies discussed above. To this end, we complement the equivalent consumption measure commonly used in the literature with a measure that takes into account the presence of disagreement between the rate of discount of the government and that of the households, following Aguiar et al. (2020). The disagreement reflects that generally, the government may be more impatient than individuals because of political economy considerations. This assumption implies that individuals prefer policies that reduce the amount of debt and the rate of default. Therefore, without disagreement, there is a potential bias in the welfare results, as gains favor policies that increase debt just because the model requires an impatient government to capture the debt dynamics of emerging markets. To the best of our knowledge, this is the first paper in the quantitative sovereign default literature that considers disagreement when evaluating policy welfare in the context of debt restructurings. Our results indicate that welfare gains are noticeably smaller when considering this effect, which suggests caution when reading into the welfare gains derived in this literature.

[3] Paragraph 11 of Communiqué G20 Finance Ministers and Central Bank Governors Meeting, G20 Web Site, 28 July 2016, available at http://www.g20.utoronto.ca/2016/160724-finance.html, last accessed February 14, 2018.

We use our quantitative framework to show that policy rules for indexing debt to GDP growth and distributing losses across investors holding bonds of different maturities yields welfare gains for a wide range of policy specifications. While we consider simple parametric rules, our setup is designed as a general platform to perform more exhaustive searches for rules that maximize welfare gains.

Our study is the first to evaluate indexation and investor loss distribution policies in a model with endogenous debt maturity and restructuring. Such model features capture well-documented stylized facts of sovereign debt and are essential to correctly evaluate the policies we study. Our findings of welfare gains via the redistribution of losses of investors of different maturities rely on an analysis that would be unfeasible without a maturity choice framework like the one we consider. Similarly, our findings of welfare gains due to debt indexation speak to the "too little, too late" concern regarding restructurings raised by Guzman et al. (2016) and others. In this regard, the high exit yields generally observed in the data are consistent with the notion that countries tend to be quite vulnerable to a recurring default immediately after a restructuring. Therefore, it is particularly valuable for the country to have access to a risk-sharing debt instrument during reentry to credit markets. Finally, while the quantitative default literature has given more attention to GDP indexation policies than to investors' loss redistribution policies, our welfare results indicate that the gains of the two policies are of similar magnitude. In this way, our findings suggest that more attention should be paid to creditor loss distribution policies. Finally, the joint implementation of the policies delivers larger welfare gains that suggest some amplification effects are present.

Our analysis builds on the literature of sovereign default models initiated by Eaton and Gersovitz (1981) and mainly borrows from three branches of this literature. First, we relate to studies on sovereign default and maturity choice. While a significant portion of the literature on quantitative models of sovereign debt default has used one-period debt (e.g., Aguiar and Gopinath, 2006; Arellano, 2008) or exogenous long-maturity bonds following Hatchondo and Martinez (2009), the endogenous maturity choice approach in our model is necessary for evaluating any policies involving the distribution of maturity holdings across investors. Our model of debt maturity choice, following Sánchez et al. (2018), is simply the choice of a discrete number of periods for which the country promises to make constant payments. This approach has proven computationally convenient for applying dynamic discrete choice methods. The alternative model of maturity choice, developed by Arellano and Ramanarayanan (2012), allows for the choice of duration (not maturity) with a perpetual bond that promises payments decaying at a fixed rate and a 1-period bond. Thus, payments are concentrated in the year after issuance, a feature that is quite inconvenient to represent issuances after debt restructurings.

Second, our paper closely relates to recent models on sovereign default and restructurings. The first model that combined the Eaton and Gersovitz (1981) framework with debt renegotiation was the study by Yue (2010) that considered a Nash bargaining approach. Asonuma and Trebesch (2016) and Asonuma and Joo (2020) study different aspects of sovereign debt restructurings in the context of one-period bond models. Mihalache (2020) explores sovereign debt restructurings and maturity extensions based on political economy considerations, and maturity choice as in Arellano and Ramanarayanan (2012). Recent complementary work by Arellano et al. (2019) focuses on the role of partial defaults on restructuring dynamics.[4]

We extend the model of sovereign debt default and renegotiation developed by Dvorkin et al. (2021), which accounts for the most salient features of debt restructurings such as delays, haircuts, and maturity extensions, by incorporating the policy dimensions mentioned earlier. The focus in Dvorkin et al. (2021) is to understand the key determinants of face-value haircuts and debt maturity extensions that are a prevalent feature of the resolution of sovereign debt crises observed in the data. Our analysis here extends that framework to incorporate (i) a rule to redistribute losses among holders of different maturity and (ii) a rule to adjust yearly debt payments as a function of output growth. The main contribution is on studying the effects of these policy proposals on the behavior of creditors and debtors away and around default.[5] Specifically, here

[4]There is also an analysis of debt restructuring in a simple two-periods model by Fernandez and Martin (2014). They discuss the gains of policy interventions in restructuring using a two-period model with legacy debt maturing in the first period ("short term debt") and in the second period ("long-term debt"). They find that the redistribution of losses across holders of different maturity does not matter. Having only two periods does not allow for our maturity mechanism to work. With more than two periods there would be maturity choice also in the intermediate period and the redistribution policy would help to prevent defaults, as we show.

[5]As in Dvorkin et al. (2021), here we also build on the endogenous maturity framework developed in Sánchez et al. (2018), in which the maturity of the debt portfolio is a discrete variable. However, the latter paper abstracts from sovereign debt restructuring and policies affecting the resolution of sovereign debt crises.

we study how different restructuring policies affect the cost of borrowing at different horizons, the unconditional probability of default, the chances that countries default shortly after restructuring, and welfare.

Last, our paper relates to studies on sovereign default that analyze GDP-indexed bonds, such as Sandleris et al. (2009), Hatchondo and Martinez (2012), Barr et al. (2014), and more recently Roch and Roldán (2021). In contrast to our study, such papers do not consider issuing these bonds exclusively after restructuring. An advantage of considering the issuance of GDP-indexed bonds exclusively in restructuring is that they have a significant economic impact while only modestly modifying the current regulatory framework. The driver of this finding is that countries remain excluded from financial markets for several years following a debt restructuring episodes, as shown by Cruces and Trebesch (2013). Having a policy that represents a small change to the status quo should make it a more appealing to international investors, which should help alleviate adoption and liquidity concerns of these instruments, a problem that is generally associated with indexed bonds.

In addition, the literature considers indexed bonds in models that exclude endogenous restructuring, have short-term bonds or exogenous maturity, and that generally do not distinguish GDP warrants from GDP-linked debt instruments. Our results highlight the importance of including these features. For example, the introduction of these bonds have a significant effect on haircuts, something that previous literature failed to capture.[6]

The remainder of the paper is organized as follows. Section 2 presents the two policy interventions under study, section 3 introduces the modeling framework to evaluate the policies, section 4 describes the calibration of the model and its quantitative business cycle properties, section 5 extends the basic model to incorporate the policy interventions, while section 6 evaluates the implications of each of the policy interventions in restructurings for debt price, maturity profile, and quantity dynamics. Section 7 evaluates the welfare implications of each policy, and section 8 evaluates the robustness of the results to different economic characteristics of the sovereign. Last, section 9 assesses the effects of the joint implementation of the two policies on key debt

[6] Our work also relates to studies discussing other types of default resolution or prevention mechanisms (e.g., Bianchi, 2016; Roch and Uhlig, 2016).

and macroeconomic moments, and section 10 concludes.

2 Previous Proposals and International Experience

This section discusses proposals for sovereign debt restructuring arrangements and related international experiences that we analyze in the following sections using a quantitative model of sovereign default with endogenous restructuring and debt maturity choice.

2.1 A Rule for Distributing Losses across Creditors

A key issue affecting coordination among bondholders in sovereign debt restructurings is that it is unclear how to redistribute the losses across creditors holding bonds of different maturities. In particular, as shown empirically by Asonuma et al. (2015), creditors with short maturity securities tended to suffer significantly more losses than creditors with long maturity securities during recent sovereign debt restructuring episodes. We evaluate the implementation of a mechanism that determines how to redistribute losses.

Proposals for strengthening the arrangements for sovereign debt restructurings aim to restructure unsustainable debt more orderly, predictably, and rapidly. The IMF has recognized that achieving these objectives requires addressing several weaknesses in the existing sovereign debt restructuring system.[7] One aspect of restructurings where these challenges are present involves the way different types of creditors can "vote" for a debt resolution mechanism, and how to aggregate their choices. Notwithstanding the potential benefits of aggregation, on different occasions the IMF has highlighted the fear that strong aggregation mechanisms could lead to inter-creditor equity concerns where, for example, a majority of creditors holding a certain type of claims impose an agreement on a minority of creditors that hold very different claims. Such a problem could arise where the aggregation involves claims of different seniority or where the claims being aggregated continue to have different maturities.[8] Clearly, creditors with differing residual maturities have differing economic interests. If all creditors holding non-defaulted claims

[7] See IMF (2003a).

[8] See IMF (2003b) and IMF (2013b)

were forced to accept the same long-term instrument in a restructuring, creditors holding claims with relatively short residual maturities would bear a disproportionate burden compared to those holding claims with relatively long residual maturities[9].

This "one size fits all" approach was implemented in the Greek sovereign debt restructuring in 2011-2012. The symmetric treatment of bonds in Greece created much larger NPV haircuts for holders of shorter-dated bonds. Zettelmeyer et al. (2013) consider alternative ways that could have increased debt relief or reduced the large amount of EFSF[10]-financed cash incentives. From that perspective, the study argues that the "one size fits all" approach of offering the same bundle of new bonds and cash to all investors, irrespective of the maturity of their old bonds, and with no distinction between foreign law bonds and Greek law bonds, was the costliest mistake in the design of the Greek debt restructuring. They show that imposing a 70 percent haircut on all investors would have resulted in an additional debt relief of almost €30 billion in face value terms and €23 billion in present value terms. A 70 percent haircut would have been lower than the haircut that was deemed to be acceptable for short-term creditors (about 80 percent), and thus surely feasible. The work by Zettelmeyer et al. (2013) also points out three reasons motivating the one-size-fits all approach: First, the intention to keep things simple in order to get the deal done before March 20, 2012 when the next very large bond was coming due (€14.4 billion); second, that the members of the creditor committee were likely mostly invested in longer-dated Greek instruments; and third, that the so-called Troika[11], Greece, and the creditor committee may have been sympathetic to taking a tough approach against short-term creditors, many of which had deliberately bought short-dated instruments at large discounts in the hope of still being repaid in full.

The above discussion of the aggregation of creditor claims and the corresponding distribution of creditor losses during the Greek sovereign debt restructuring applies to other episodes. The "one size fits all" resolution approach has been documented for other exchanges, including

[9]Other contractual features equal, a longer relative maturity extension implies a larger reduction in the present value of the claim

[10]European Financial Stability Facility

[11]Troika in the context of the Greek debt restructuring refers to the European Debt Commission, the European Central Bank, and the International Monetary Fund

Pakistan in 1999, Moldova in 2002, and Cote D'Ivoire in 2010. While restructurings offering the same menu of new instruments across creditors tilt losses toward short-term bondholders, Asonuma et al. (2015) reports more generally a difference in haircuts associated with a difference in the maturity of instruments, where haircuts on short-term debt are more extensive than those on long-term debt. Over their sample of recent restructurings, the study documents an average difference of 17.2 percent in haircuts on short-term versus long-term debt.

Therefore, the analysis of the distribution of losses across creditors holding instruments of different maturities can help make the process of debt restructuring more predictable by improving creditor coordination and facilitating the resolution of inter-creditor equity concerns. Such changes to creditors' conditions during restructurings may directly affect bond pricing and bondholding incentives across maturities, impacting a country's default incentives and welfare. Our analysis quantitatively evaluates these transmission channels.

2.2 GDP-Indexed Bonds Issued in Restructurings

Since the theoretical arguments in favor of contingent debt for sovereigns discussed by Krugman (1988) and Froot et al. (1989), and the work by Shiller (1993) proposing the idea of GDP-indexed bonds, it has been increasingly discussed in academic and policymaker circles. The idea behind these instruments is straightforward: by improving risk-sharing between the borrowing country and international creditors, GDP-indexed bonds may diminish the probability of debt crises and increase welfare. The string of sovereign debt crises, especially since the 2000s, renewed the interest in using GDP-indexed debt as part of the design of sovereign debt contracts. Drèze (2000) suggested the use of GDP-indexed bonds as part of a strategy to restructure the debt of the poorest countries.

In 2001, Argentina experienced one of the largest sovereign debt defaults in emerging markets. In March 2005, Argentina concluded the restructuring of its debt. One distinctive element of the restructured debt was that it included an instrument called GDP-warrant, whereby a sizeable share of the debt payments was linked to the evolution of Argentina's GDP.

A few years later, the European debt crisis led policymakers to ponder once again the possibility of issuing debt indexed to real variables (i.e., real-indexed debt contracts). Under the Greek debt exchange terms in March 2012, Greek bondholders were offered three new securities in exchange for existing Greek bonds: One and two-year EFSF bonds and new 30 year global greek bonds (GGBs) with a step-up coupon and GDP warrants. The GDP warrants were a small sweetener, equivalent to about 0.2 percent of the original notional, or around 400 million euros. The GDP warrants were set to mature on October 15, 2042.

More recently, Ukraine issued GDP-linked securities, known as warrants, to creditors who wrote down 20 percent of bonds' original values as part of a 2015 debt restructuring. The warrants pay out if Ukraine's economic growth exceeds certain thresholds.[12]

The IMF (2017) acknowledges that, in spite of potential benefits for using GDP-indexed bonds, the frequency of these instruments in the financial markets is rather low. Accordingly, the report suggests a potential role for the IMF to facilitate the take-up of these assets. More recently, and largely motivated by the macroeconomic uncertainty and debt sustainability concerns in several emerging economies as a result of the COVID-19 pandemic, the IMF (2020) has strongly emphasized the relevance and encouraged the exploration of state contingent debt instruments in the specific context of sovereign debt restructurings.

Our paper analyzes both qualitatively and quantitatively how the introduction of GDP-indexed sovereign debt contracts affects borrowing, default, and the outcome of debt restructurings.

3 A Laboratory for Policy Evaluation

We consider a small open endowment economy a la Eaton and Gersovitz (1981) with a government and hand-to-mouth consumers. The government participates in international credit markets where lenders are risk-neutral. It cannot commit to repaying its obligations, so it has two actions to choose from, given an outstanding amount of assets, b (debt if $b < 0$). The first option is to pay its obligations and hence keep its good credit status. Alternatively, the government may decide not to make its debt payment, i.e., default. After default, the country faces some

[12]See Borensztein and Mauro (2002) for an early analysis of GDP-indexed bonds.

periods of financial autarky and an output loss. In the following periods, the government may restructure its debt and get back to international credit markets.

In times of good credit status, the country may face two regimes in international credit markets. Normal times are represented by $a = 0$, and times of distress in international credit markets are represented by $a = 1$. In times of distress, the government does not have access to borrowing and is limited to making the promised payments or default.[13]

The default decision is also influenced by the current level of debt, b, and its maturity, m, by the country's income, y, which fluctuates exogenously over time, by the costs of default, and by the expected terms of the restructuring.

The conditions of the debt restructuring are endogenously determined as in Dvorkin et al. (2021). Each period in default, either the lender or the borrower has a chance to make a restructuring offer to the other party. Once there is an agreement on the value of the new debt, the country chooses the maturity of that debt conditional on delivering the agreed market value of the new bonds.

3.1 The problem of the sovereign in good credit standing

The value for the country when in good standing is

$$V^G(y, a, b, m) = \max \left\{ V^D(y, b, m), V^P(y, a, b, m) \right\},$$

where V^D and V^P are the values if the country chooses to default and pay its debt, respectively. The policy function for default $D(y, a, b, m)$ takes value 1 if default is chosen, and 0 otherwise.

The value in case of default is

$$V^D(y, b, m) = u(y^D) + \beta E_{y'|y^D} V^R(y', b, m),$$

where $y^D = \min\{y, \pi\}$ captures the default cost on endowment. V^R is the value of a country in

[13]We relate these episodes of financial distress in international markets as sudden stops of capital flows which affect a large number of emerging market economies at the same time and are not closely linked to changes in fundamentals of individual countries.

restructuring that will be explained in the next subsection.

Countries may issue bonds with different maturities when they are in good credit standing. Since modeling a debt portfolio with many different types of bonds in terms of per-period payments and maturity would make the problem computationally intractable, we impose a restriction on the structure of the debt portfolio following Sánchez et al. (2018). We assume that, at any point in time, the debt portfolio is characterized by the promised level of per-period payment, b, and by the number of periods that these payments will be made (debt maturity), m. The government optimally chooses b and m when it borrows. The portfolio may consist of any number of bonds, and whether it is composed of a single bond or several bonds is irrelevant in this framework, as we show next with some examples. The key restriction is that the profile of payments of the selected debt portfolio is constant, so the portfolio can be characterized with just two state variables, (b, m), making the problem tractable.[14]

Thus, a country's "bond portfolio" is described by a fixed payment, b, and its maturity, m, and its value is $b \times q(y, a, b, m; m)$. As the portfolio may consist of any number of bonds, the value of a portfolio that pays $\tilde{b} < b$ for m, given a country's portfolio characterized by (b, m), is simply $\tilde{b} \times q(y, a, b, m; m)$. This pricing is possible because q is the price per unit of the yearly payment. To interpret the "m" after the semicolon, note that, given a country's portfolio characterized by (b, m), the market value of a bond that pays $\tilde{b} < b$ for $n < m$ periods is $\tilde{b} \times q(y, a, b, m; n)$. Similarly, we can obtain the market value of a (zero coupon) bond that pays $\tilde{b} < b$ in m years, given a country's portfolio characterized by (b, m), by just subtracting the value of two different portfolios, $\tilde{b} \times [q(y, a, b, m; m) - q(y, a, b, m; m-1)]$.[15]

[14]For simplicity we assume the same payment b each period until the bond fully matures. However, it is possible to relax this assumption and have a bond portfolio with a different payment profile, either increasing or decreasing over time. This would not add important computational costs to the extent that this profile is exogenously parameterized.

[15]To further illustrate our notation, consider the following example. Suppose that the country has a debt portfolio with maturity of four periods and total per-period payment of b, that is, $\{b, b, b, b\}$. Assume that the portfolio consists of three bonds with payment promises

$$\{\underline{b}, \underline{b}, \underline{b}, 0\}, \tag{bond 1}$$

$$\{b - \underline{b}, b - \underline{b}, b - \underline{b}, 0\}, \text{ and} \tag{bond 2}$$

$$\{0, 0, 0, b\}. \tag{bond 3}$$

With this notation at hand, the value if the country repays the debt is

$$V^P(y,0,b,m) = \max_{b',m'} u(c) + \beta E_{y',a'|y,0} V^G(y',a',b',m'),$$

subject to

$$c \quad = \quad y + b - \underbrace{q(y,0,b',m';m')b'}_{\text{market value of new debt}} + \underbrace{q(y,0,b',m';m-1)b}_{\text{market value of old debt}}.$$

The country chooses an integer $m' \in \{1,2,...,M\}$ representing the number of periods that will make payments of b'.[16] Reading the constraint suggests that the government sells a new bond that promises to pay b' for m' periods and it buys the old debt (or a bond that pays b for $m-1$ periods) at market prices, $q(y,0,b',m';m-1)b$. Here q depends on b',m' because prices are forward looking and these two values describe the state of the country in the next period. Note also that this price is multiplied by the old size of payments, b, and is has $m-1$ after the semi-colon because the old payments of b were promised last period for m periods and one payment has been made, resulting in $m-1$ payments outstanding.[17]

Note that since the repurchase transaction in this representation happens at market prices, this constraint can be rewritten such that the interpretation is that countries issue only the difference between the old portfolio (after this period's repayment) and the desired one, as represented in Figure 1. Adding and subtracting $bq(y,0,b',m';m') + (b'-b)q(y,0,b',m';m-1)$

The value of each bond is

$$\underline{b} \times q(y,a,b,4;3), \qquad \text{(bond 1)}$$

$$(b-\underline{b}) \times q(y,a,b,4;3), \text{ and} \qquad \text{(bond 2)}$$

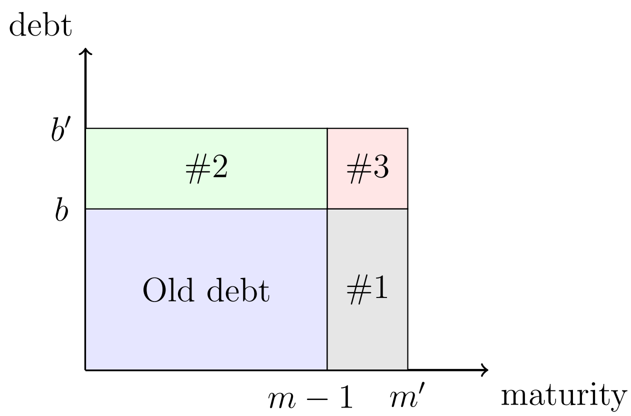
$$b \times [q(y,a,b,4;4) - q(y,a,,b,4;3)], \qquad \text{(bond 3)}$$

respectively. Adding the value of these three bonds we obtain the value of the portfolio, $b \times q(y,a,b,4;4)$. These prices provide very useful notation for the country's choice of maturity and highlight that a wide array of bonds can conform the total borrowing portfolio of the country in our setup.

[16] Since our calibration is yearly, choosing $M = 20$ is enough to guarantee that there is no instance in which countries would like to choose $m' > M$.

[17] Note that in the special case of $m = 1$, the country's legacy debt consisted of one-period bonds, thus the constraint is $c = y - b'q(y,0,b',m';m') + b$, as $q(y,a,b',m';0) = 1$, which highlights that after making the payment, the resources available for consumption expand via the new borrowing. Similarly, in the case of $m' = m-1$ we can write $c = y - (b'-b)q(y,0,b',m-1;m-1)$, which highlights that the available resources for consumption expand by the *additional* (net) borrowing.

Figure 1: Change in the country's debt portfolio



Note: This figure represents a change in the country's debt portfolio from $(b, m-1)$ to (b', m'). The new issuances are represented by the rectangles #1 and #2, and the square #3.

in the budget constraint and reorganizing terms we obtain,

$$
\begin{aligned}
c = \quad & y - \underbrace{b[q(y,0,b',m';m') - q(y,0,b',m';m-1)]}_{\text{\#1: value of changing only maturity}} - \underbrace{(b'-b)q(y,0,b',m';m-1)}_{\text{\#2: value of changing only the yearly payment}} \\
& - \underbrace{(b'-b)[q(y,0,b',m';m') - q(y,0,b',m';m-1)]}_{\text{\#3: value of changing the yearly payment by } (b'-b) \text{ only for the extra maturity } m'-(m-1)},
\end{aligned}
$$

where the first term, labeled as (#1), represents what the countries would obtain (at market prices) by changing only the value of maturity from $m-1$ to m'. The second term, labeled as (#2), corresponds to the resources the country would obtain changing only the size of the yearly payment from b to b'. Finally, the last term, labeled as (#3), correspond to the additional resources $(b'-b)$ that are promised for an additional $m'-(m-1)$ years after the old debt matures.

Lastly, if there is a sudden stop event, the country's value is

$$V^P(y,1,b,m) = u(y+b) + \beta E_{y',a'|y,1} V^G(y',a',b,m-1).$$

The policy functions for the choice of the amount of debt and the choice of maturity are $B(y,a,b,m)$ and $M(y,a,b,m)$, respectively.

3.2 The problem of the sovereign in restructuring

When the country's debt is in restructuring, the opportunity to offer a restructured debt portfolio with market value W alters stochastically between the borrower and the set of lenders: the probability that the lender (L) makes the offer is λ, after which the sovereign (S) decides whether to accept. The probability that the sovereign has the option to make the offer is $(1-\lambda)$.

On the one hand, if the lender decides to make an offer, she will offer a value of debt portfolio equal or smaller than the face value of the defaulted debt, $W < -b \times m$. We write this problem as

$$W^L(y,b,m) = \underset{W \leq -b\times m}{\arg\max}\, W \times H(y,b,m,W),$$

where $H(y,b,m,W)$ is a function indicating the probability that the country accepts the offer. If the decision of the country whether to accept the offer or not depends only on (y,b,m,W), then H is an indicator function and the lender will offer the maximum it can so that the country will accept it. We write this problem in a more general way, using a probability, only because the country's decision to accept the offer may be affected by a random preference shock as in Dvorkin et al. (2021) and in that case $H \in (0,1)$.[18] Also, the lender makes this offer only if the value she can obtain is larger than the value of debt continuing in default; i.e., $W^L(y,b,m) \geq -bq^D(y,b,m;m)$, where q^D is the price of debt in default.

On the other hand, if the country makes the offer, it will offer a value W such that the lenders are indifferent between accepting and rejecting the offer; i.e., $W^S(y,b,m) = -bq^D(y,b,m;m)$.

Independently of how the value of W is determined, given a value W, the country chooses the yearly payment and the maturity of the restructured debt, $\{b^R, m^R\}$, and a transfer of fresh money from the lenders to the country, $\tau^R \geq 0$, such that

$$\tau^R(y,b,m,W,b^R,m^R) = q^E(y,b^R,m^R;m^R) \times (-b^R) - W - \underbrace{\kappa \max\{|b \times m| - |b^R \times m^R|, 0\}}_{\text{regulatory cost of book-value haircuts}},$$

where the price of the debt being restructured, q^E, takes into account that the country will be excluded from credit markets next period with probability δ. Note also that we add, as in

[18] More information on these shocks is provided in Section 4.

Dvorkin et al. (2021), a cost to compensate the lender for their extra cost in case of face value haircuts, which is determined by the parameter κ.

The country makes the choice of $\{b^R, m^R, \tau^R\}$ given a restructured value W and old debt (b, m) to maximize utility,

$$\begin{aligned}\tilde{V}^A(y, b, m, W) &= \max_{b^R, m^R} u(y^R + \tau(y, b, m, W, b^R, m^R)) \\ &\quad + \beta E_{y'|y^R}\left[(1-\delta)V^G(y', 0, b^R, m^R) + \delta V^E(y', b^R, m^R)\right] \\ &\quad \text{subject to } \tau^R(y, b, m, W, b^R, m^R) \geq 0,\end{aligned}$$

where $y^R = \min\left\{y, \pi^R\right\}$ represents the income net of the cost of being in restructuring, and the value function V^E represents the value of exclusion, which occurs after restructuring. This value can be written as

$$V^E(y, b, m) = \max\{u(y-b) + \beta E_{y'|y}\left[(1-\delta)V^G(y', 0, b, m-1) + \delta V^E(y', b, m-1)\right], V^D(y, b, m)\}$$

where the country leaves exclusion in any period with probability $(1-\delta)$. Note that, while in exclusion, the country must either make debt payments using current income (there is no possibility of debt rollover) or default.

We can express the value of a country in restructuring with a given offer as

$$\tilde{V}^R(y, b, m, W) = \max\left\{V^D(y, b, m); \tilde{V}^A(y, b, m, W)\right\},$$

and the value of a country in restructuring as

$$V^R(y, b, m) = \lambda \tilde{V}^R(y, b, m, W^L(y, b, m)) + (1-\lambda)\tilde{V}^R(y, b, m, W^S(y, b, m)).$$

3.3 Equilibrium debt prices

The price of a non-defaulted bond promising to pay one unit of the consumption goods for the next n periods is

$$q(y,a,b',m';n) = \frac{E_{y',a'|y,a}}{(1+r)} \Big\{ (1-D(s'))\,(1+q(y',a',B(s'),M(s');n-1)) + D(s')q^D(y',b',m';n) \Big\},$$

where we denote the relevant states for the policy functions in good times as $s' = (y',a',b',m')$. The variable a affects the price of debt indirectly through changes in the policy functions. Similarly, the price of debt during exclusion after default is

$$\begin{gathered} q^E(y,b',m';n) = \frac{E_{y'|y}}{(1+r)} \times \\ \Big\{ \delta \left[\left(1-D^E(\tilde{s}')\right) \left(1+q^E(y',b',m'-1;n-1)\right) + D^E(\tilde{s}')q^D(y',b',m';n) \right] \\ +(1-\delta)\left[(1-D(\hat{s}'))\,(1+q(y',0,B(\hat{s}'),M(\hat{s}');n-1)) + D(\hat{s}')q^D(y',b',m';n) \right] \Big\}. \end{gathered}$$

Here the notation of the relevant states for the policy functions in default is $\tilde{s}' = (y',b',m')$, and those after the end of the exclusion –where the country is surely not in a sudden stop– is $\hat{s}' = (y',0,b',m')$. The difference with the price in normal times is that with probability δ the country will not have access to credit markets again next period, and as a consequence the policy functions will be different.

Finally, the price per unit of debt in default is

$$q^D(y,b',m';n) \quad = \quad \frac{E_{y'|y}}{(1+r)} \Big\{ \left[(1-\lambda) + \lambda(1-H^L(\tilde{s}')) \right] q^D(y',b',m';n) + \lambda H^L(\tilde{s}') \left[\frac{W^L(\tilde{s}')}{-b'} \frac{n}{m'} \right] \Big\}.$$

This price has two terms. The first term reflects that if the country makes the offer (probability $1-\lambda$) or if the lender makes the offer and it is rejected (probability $\lambda(1-H^L)$), the value of the debt would continue to be the value of debt in default but in a different state $q^D(y',b',m';n)$.

The second term has the total repayment made by the country in case of a successful restructuring, $W^L(y',b',m')$, which is divided by the total amount of debt $(-b)$ because it is the price per unit of yearly payment. This value is divided among the bondholders of different maturities using the ratio n/m'. For example, if a bond in default in the debt portfolio has maturity of one period, $n = 1$, and the total maturity of the defaulted portfolio is four years, $m' = 4$, we have that $\frac{W^L(y',b',m')}{-b'}$ is multiplied by 1/4, as the one-year bond is entitled to one payment out of the four payments the country had committed to. In this case, bondholders of all maturities would be treated identically in terms of the fraction of the restructured debt they receive, irrespective of whether they originally hold short or long term debt.

4 Model Calibration and Evaluation

4.1 Calibration

To calibrate the model we take some parameters from the literature or previous estimations. For the remaining parameters, we follow Dvorkin et al. (2021) as closely as possible.

Table 1: Calibrated parameters and fit of targeted statistics

Parameter	Value	Basis	Data	Model
Discount factor, β	0.935	Debt/output	31%	36.3%
Output loss, entering default, π^D	0.90	Default rate	2.50%	2.27%
Output loss, staying in default, π^R	0.945	Length of default, years	2.30	2.40
Lender's offer prob., λ	0.55	Mean SZ haircut	32.8%	34.1%
Portfolio adj. cost, α_1	0.00005	Average issuance costs	0.2%	0.3%
Portfolio adj. cost, α_2	20	Δ Debt/GDP near default	22p.p.	20p.p.

Note: See data sources in Appendix A. SZ haircut refers to the haircut measure proposed by Sturzenegger and Zettelmeyer (2006) and it is defined in Appendix B.

The risk aversion parameter, γ, is set at 2, a value widely used in the literature. The risk free interest rate is set at 4.2% to match the long-run average of the real 10-year US Treasury bond yield between 1980 and 2010. Income follows an AR(1) process in logs with persistence parameter $\rho_z = 0.86$ and the volatility parameter $\sigma_z = 0.019$ to mimic the detrended annual per capita real GDP process for Colombia as estimated in Sánchez et al. (2018).

We set the regulatory cost of lenders' book value losses at 3%, so κ is set at 0.03. This is a conservative value associated to institutional lenders' cost of raising capital due to adjustments in the face value of the portfolio in restructuring. The probability of remaining in exclusion after restructuring a debt portfolio, δ, is set at 0.7 to match the 70% probability of such event estimated from the data in Cruces and Trebesch (2013) for emerging markets. Sudden stops are modelled as a Markov process with a probability of experiencing a sudden stop of 12% next period if not in this state at present, and a probability of 42% of continuing in a sudden stop state, based on the definition of sudden stop in Comelli (2015) and controlling for domestic credit conditions.

We also introduce adjustment costs for changing the debt portfolio in order to capture issuance costs. Both changes in maturity and changes in the size of yearly payments are assumed to be costly.[19] The portfolio adjustment cost function has two parameters, α_1 and α_2, that are set at 0.00005 and 20, respectively, to replicate the average issuance costs and the variation in debt-to-GDP ratio prior to default.

We calibrate the remaining parameters targeting data for Colombia—an emerging market economy with good data availability. The discount factor β is set at 0.935 targeting a 31% debt-to-output ratio. The output loss parameter for the first period in default, π, is set at 0.90 targeting a 2.5% default rate, while the output loss for other periods in default, π^R, is set at 0.945 targeting the length of a default episode of 2.3 years. The probability of the lenders making the offer for restructuring, λ is set at 0.55 targeting a 33% haircut rate.

For the numerical solution of the model, we add taste shocks drawn from a Generalized Extreme Value distribution for each possible choice of the government (maturity, borrowing, repayment, and accepting a renegotiation deal). This dynamic discrete choice procedure method, introduced to sovereign default by Dvorkin et al. (2021), facilitates convergence by smoothing out the policy functions. We follow that paper in the values assigned to the parameters associated with the distribution of these shocks.

[19] We use the functional form $\chi(b, m, b', m') = \alpha_1 \exp\left(\alpha_2 \left(\frac{m+m'}{2}|b-b'| - \frac{b+b'}{2}|m-m'|\right)\right) - \alpha_1$, where $-b$ and m are the level and maturity of the debt portfolio, respectively, after making the current payment, and $-b'$ and m' are those of the newly issued debt.

4.2 Evaluation

In the previous sections we introduced and calibrated our model of debt maturity choice and distressed debt restructuring. In this section we evaluate the quantitative performance of the model comparing several of its non-targeted moments with the data from Brazil, Chile, Colombia, and Mexico, a set of frequently studied emerging market economies. The model does remarkably well in capturing the business cycle properties of sovereign debt along several dimensions. We present all statistics in Table 2.

Table 2: Fit of key non-targeted moments

Statistics	Brazil	Chile	Colombia	Mexico	Model
$\sigma(log(c))/\sigma(log(y))$	1.30	1.47	1.15	1.59	1.16
$\rho(log(c), log(y))$	0.40	0.84	0.82	0.67	0.83
Duration (years)	3.65	4.44	5.23	5.76	3.67
Maturity (years)	6.47	5.53	9.62	11.43	6.75
$\rho(mat, log(y))$	0.03	-0.30	0.19	0.24	0.43
$\rho(dur, log(y))$	0.06	-0.32	0.34	0.02	0.33
1-year spread (%)	1.93	0.48	0.82	1.32	0.83
10-year spread (%)	4.52	0.86	2.11	3.41	0.90
$10YS - 1YS(\%)$	2.59	0.22	1.30	2.08	0.07
$\rho(1YS, log(y))$	-0.04	-0.33	-0.23	-0.01	-0.18
$\rho(10YS, log(y))$	-0.21	-0.12	-0.68	-0.09	-0.49

Note: The first-order moments are country-specific means in the data and in the model. See data sources in Appendix A.

The table shows that our model closely mimics several non-targeted standard business cycle moments for emerging market economies. Our framework closely captures the volatility of consumption relative to output volatility above one and the high correlation of consumption with output documented in the data. The model also reproduces the median sovereign debt maturity and duration from the data and their business cycle dynamics. The average duration is 3.67 years, and the average maturity in the model is 6.75 years. While these two statistics are slightly below the averages of our data sample, the model generates the procyclical pattern for debt maturity and duration found in the data. We also evaluate the model in terms of the level and cyclicality of 1- and 10-year spreads, and the term premium. Our setup captures well the countercyclical dynamics of yield spreads for different bond maturities over the business cycle.

5 Policy Interventions: Extending the Model

This section introduces two commonly discussed policy proposals in debt restructurings, that could be implemented for instance in the context of an IMF-sponsored program. Distressed debt restructurings already typically involve the participation of the IMF, and as discussed in the IMF (2014), of the 17 arrangements reviewed in an IMF report for the period from 1998 to 2014, 11 included conditionalities related to the restructuring. The policy exercises we study here focus on standardized procedures across debt restructurings instead of a discretionary rule. Erce (2013) suggests a standardized role for IMF in its approach to restructurings can be beneficial by reducing the uncertainty when countries enter into a sovereign default crisis.[20]

For the two policy proposals we analyze, i.e., a rule for distributing losses across creditors and the use of GDP-indexed bonds, we study how they affect, among other things, sovereign debt prices, maturity, and the frequency of defaults both shortly after a restructuring and over the long term. The potential welfare gains are analyzed in the next section.

5.1 A Rule for Distributing Losses Across Creditors

In the model presented above, the proceedings of restructuring are distributed to holders of bonds of different maturities proportionally to the number of yearly payments, n/m'. In this section we extend the model to distribute these proceedings according to

$$\text{distribution rule} = \frac{q^*(n; r^R)}{q^*(m'; r^R)},$$

where n is the maturity of a bond, m' is that of the entire portfolio, and $q^*(k, r) = \sum_{l=1}^{k} \frac{1}{(1+r^R)^l}$. This representation allows for a different treatment of long maturity debt *vis-a-vis* short maturity

[20]A roadmap developed and published by the United Nations Conference on Trade and Development calls for a clear procedure for sovereign debt renegotiations, which can be established by standardized rules guiding these procedures. (See UNCTAD (2015).)

debt in the defaulted portfolio. The price of the debt in default is now

$$q^D(y,b',m';n) \quad = \quad \frac{E_{y'|y}}{(1+r)}\left\{\left[(1-\lambda)+\lambda(1-H^L(\tilde{s}'))\right]q^D(y',b',m';n)+\lambda H^L(\tilde{s}')\left[\frac{W^L(\tilde{s}')}{-b'}\frac{q^*(n;r^R)}{q^*(m';r^R)}\right]\right\}.$$

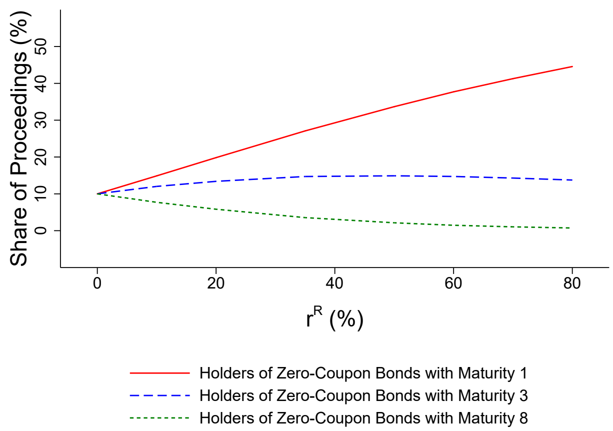
Here, $q^*(n;r^R)$ is the present value of n payments, discounted at rate r^R, which in turn shapes the relative returns for each maturity. Intuitively, consider a simple example of a debt restructuring with two creditors. The first creditor holds a bond that matures in the current period (shorter-term bond) and has a face value of \$60. The second creditor holds a bond that matures in one year (longer-term bond) and also has a face value of \$60. The country defaults on these bonds and the lenders and the country agree to a restructuring, issuing new bonds with a total market value of \$100. If the discount rate r^R used for determining the recovery payments to the creditors is zero (i.e., $r^R = 0$), both the creditor with the shorter-term bond and the creditor with the longer-term bond receive \$50 according to the distribution rule $\frac{q^*(n;r^R)}{q^*(m;r^R)} = \frac{n}{m} = \frac{1}{2}$. Thus, $r^R = 0$ is the case in which the extended model with a redistribution rule nests the benchmark model. Higher discount rates will lower the present value received by the holder of long-term debt relative to the present value received by the holder of short-term debt. Accordingly, our discount rule determines the losses to creditors holding bonds of different maturities.

To further illustrate the direct implications of changing r^R on the distribution of creditor losses across maturity holdings, we construct the shares of the total value that the country repays in default obtained by holders of zero-coupon bonds of maturities 1, 3, and 8 years. These values can be represented as follows:

- share obtained by bondholders of 1-year maturity zero-coupon bonds $= \frac{q^*(1;r^R)}{q^*(10;r^R)}$,
- share obtained by bondholders of 3-year maturity zero-coupon bonds $= \frac{q^*(3;r^R)}{q^*(10;r^R)} - \frac{q^*(2;r^R)}{q^*(10;r^R)}$,
- share obtained by bondholders of 8-year maturity zero-coupon bonds $= \frac{q^*(8;r^R)}{q^*(10;r^R)} - \frac{q^*(7;r^R)}{q^*(10;r^R)}$.

Figure 2 shows how these values change as a function of r^R. If we set $r^R = 0$, the creditors holding bonds of different maturity will get the same share—if the total maturity is 10 years as in this example, that share is 1/10, i.e., 10%. As r^R increases along the x axis, the share obtained by bondholders of 1-year maturity zero-coupon bonds (red line) increases, the share obtained by bondholders of 8-year maturity zero-coupon bonds (dashed green line) decreases, and the share obtained by bondholders of an instrument with intermediate maturity varies more moderately. Notice that in the extreme case where $r^R = 80\%$, the share obtained by bondholders of 1-year maturity zero-coupon bonds is close to 50 percent.

Figure 2: Share of Restructuring Proceedings Obtained
by Bondholders of Selected Maturities



Note: The figure shows the shares obtained by the holders of a bond of maturity $n = \{1, 3, 8\}$ in a portfolio of maturity $m = 10$. We plot these shares for different redistribution rules represented by r^R.

5.2 GDP-indexed bonds

We introduce new notation to capture the fact that the country can now issue GDP-indexed bonds during debt restructurings. Let $\Psi(y'/y)$ be the factor by which the debt payment is adjusted as a function of the change in income, y'/y. We use $\Psi(y'/y)$ as an step function, where

$$\Psi(y'/y) = \begin{cases} 1 + \Delta_H & \text{if } y'/y > 1.03 \\ 1 & \text{if } 1 \leq y'/y \leq 1.03 \\ 1 - \Delta_L & \text{if } y'/y < 1.00. \end{cases}$$

The thresholds for indexation are set at 1 and 1.03 as, on average, upon exiting a restructuring, economies recover at an annual real GDP growth rate between 1 and 2 percent (Dvorkin et al., 2021). As we explained in the case of redistributing losses among maturities, the exercise aims to show the effect of this simple rule and not look for the optimal rule.

With this notation at hand, we can modify the expression for the value function of the country in restructuring accordingly. The new value is

$$\begin{aligned} V^E(y,b,m) &= u(y-b) + \beta E_{y'|y}\left[(1-\delta)V^G(y',0,b\Psi(y'/y),m-1)\right. \\ &\qquad \left. + \delta V^E(y',b\Psi(y'/y),m-1)\right]. \end{aligned}$$

Note that, unlike previous literature on contingent debt, we introduce indexed bonds only at the time of restructuring. Thus, during the years after the restructuring in which the country is excluded from financial markets, if the country's income increases above 3%, the outstanding yearly payments of the restructured debt increase by the factor Δ_H. In addition, in the case we referred to as "symmetric", yearly payments decrease by a factor of Δ_L if income decreases. This indexation rule lasts while the country is in exclusion. Since the country leaves exclusion in any period with probability $\delta = 0.75$, the expected duration of the period in which the changes may take place is 3 years.

Similarly, we also have to modify the price of debt used during restructuring,

$$\begin{gathered} q^E(y,b',m';n) = \\ \frac{E_{y'|y}}{1+r}\Psi(y'/y)\Big\{\delta\Big[\left(1-D^E(y',b'\Psi(y'/y),m')\right)\left(1+\mathbf{q^E}\right) + D^E(y',b'\Psi(y'/y),m')\mathbf{q^D}\Big] \\ +(1-\delta)\Big[\left(1-D(y',0,b'\Psi(y'/y),m')\right)(1+\mathbf{q}) + D(y',0,b'\Psi(y'/y),m')\mathbf{q^D}\Big]\Big\}, \end{gathered}$$

where

$$\begin{aligned} \mathbf{q^E} &= q^E(y',\Psi(y'/y)b',m'-1;n-1), \\ \mathbf{q^D} &= q^D(y',b'\Psi(y'/y),m';n), \\ \mathbf{q} &= q(y',0,B(y',0,b'\Psi(y'/y),m'),M(y',0,b'\Psi(y'/y),m');n-1). \end{aligned}$$

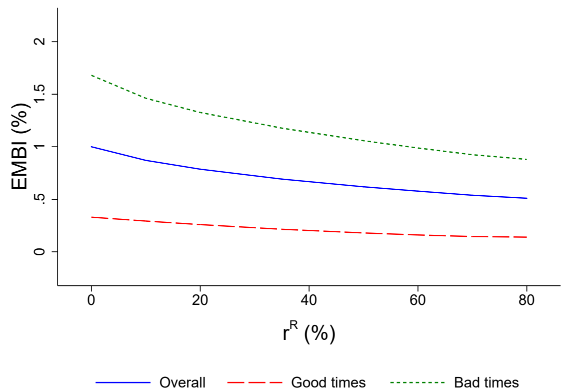
6 Policy Interventions: Quantitative Results

This section quantitatively evaluates the two policy proposals introduced in the previous section, and provides intuition regarding the main findings on debt dynamics, pricing, and other key macro outcomes over the business cycle as well as during and after default and restructuring.

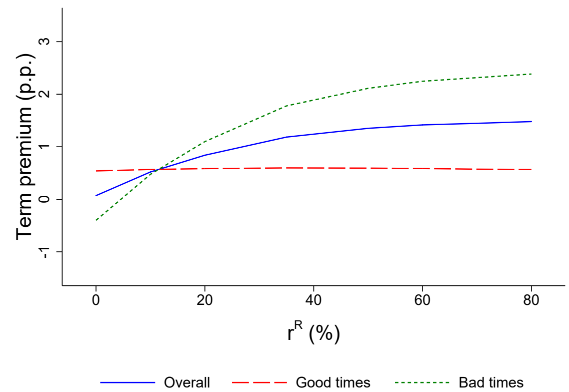
6.1 A Rule for Distributing Losses Across Creditors

We compare economies with different loss redistribution rules across creditors holding bonds of different maturity, where each rule is associated to a value of r^R. The panels in figure 3 show that the effects on credit spreads are significant, and suggest that policies that tend to favor short-term bondholders in restructurings lead to a decline in the average spread and term premium mainly in bad times, largely due to lower short-term spreads. Panel (a) shows that as r^R increases, the average EMBI spread decreases monotonically, and mainly in years in which the country's income is below trend (bad times). This result suggests that increasing r^R may be desirable. Meanwhile, panel (b) shows that the term premium measured by the 10-1-year spread increases by 1 percentage point overall (blue line): As r^R increases, holders of long-term debt receive a lower share of the restructured debt, so the spread for long-term debt is higher. The effect of the policy on the term premium is mainly driven by its impact during bad times. As shown by the green line in the plot, in bad times the term premium increases about 3 percentage points for the higher r^R values. Panel (c) shows that the lower EMBI spread and higher 10-1-year bond term premium in bad times as r^R increases are mainly driven by a decline in the spread for short-term bonds (1-year bond yield spreads), not for long-term bonds (10-year bond yield spreads).

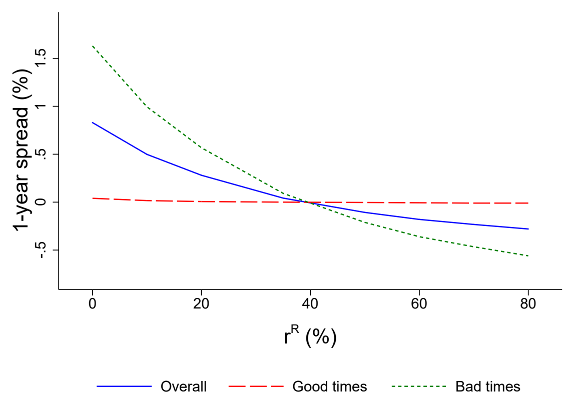
Figure 3: Effects on Debt Pricing of A Rule for Distributing Losses Across Creditors of Different Maturities



(a) EMBI



(b) Term Premium, 10-1-year spreads

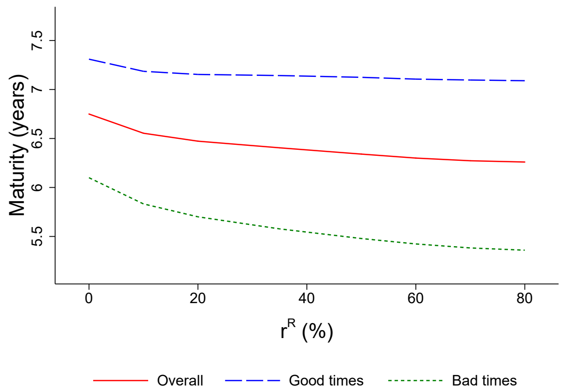


(c) 1-year spreads

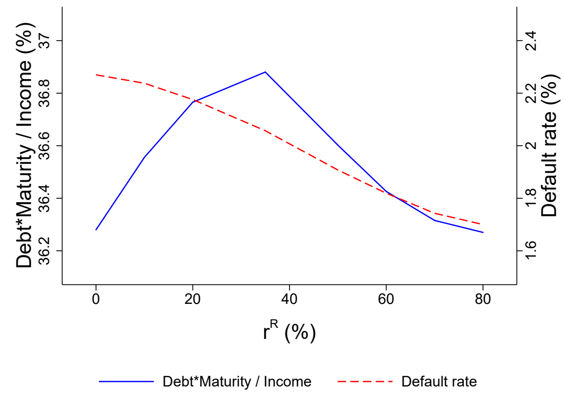
Note: In the model, bad times are years where log-income is below its mean.

Consistent with the discussion of figure 3, we find that, as r^R increases, maturity becomes lower particularly in bad times to take advantage of the lower financing cost at short maturities during those periods, as shown by the green dotted line in Figure 4, panel (a). This behavior implies that maturity becomes more cyclical. Notably, as displayed in panel (b), countries can avoid more defaults because of this lower cost of short-term debt in bad times. The default rate falls monotonically from about 2.3 percent to 1.7 percent, a reduction of more than 25 percent. Leverage is non-monotonic in the redistribution policy, initially increasing with r^R and then decreasing. Finally, panel (c) suggests that as loss redistribution policies favor short-term bond holders more, debt restructurings tend to rely more on debt maturity extensions and less on face value haircuts, and the average SZ haircut edges lower on net. Changes in maturity extensions and face value haircuts are noticeably nonlinear in the policy, with most variation occurring for values of r^R below 40 percent. Within this policy parameter range, the median maturity extension increases about four-fold, from about 2.5 years to almost 10 years, while face value haircuts more than halve, dropping from about 9 years to about 4 years. As the policy tilts the debt maturity profile toward shorter term debt especially in bad times when output tends to be low and the country is closer to default, and the country engages in a restructuring when output recovers, a restructuring that relies more on maturity extensions and less on face value haircuts takes the country closer to its preferred maturity profile, given the procyclicality of debt maturity. The stronger reliance on maturity extensions vis-a-vis face value haircuts that the policy incentivates, brings the restructuring more in line with the restructuring approach advocated by recent IMF work that argues in favor of considering more reprofilings when addressing distressed debt negotiations (IMF, 2017). Note that all these significant changes are achieved with a simple parametric rule for redistributing creditor losses by debt maturity. The goal here is not to look for the optimal rule, which may depend on the calibration, but to show how a simple rule can significantly affect the outcome of debt restructurings.

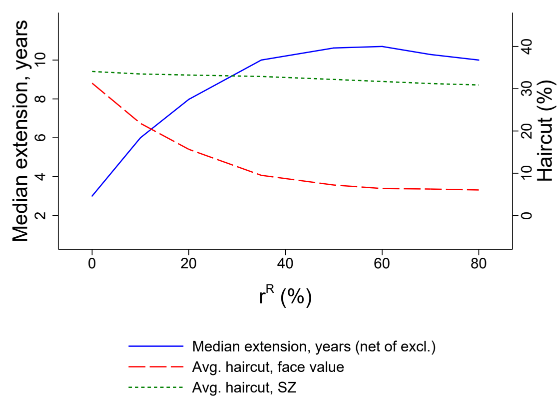
Figure 4: Effect of a on Debt, Default, and Restructuring



(a) Maturity



(b) Debt and default



(c) Extension and haircuts

Note: In the model, bad times are years where log-income is below its mean. SZ haircut refers to the haircut measure proposed by Sturzenegger and Zettelmeyer (2006) and it is defined in Appendix B.

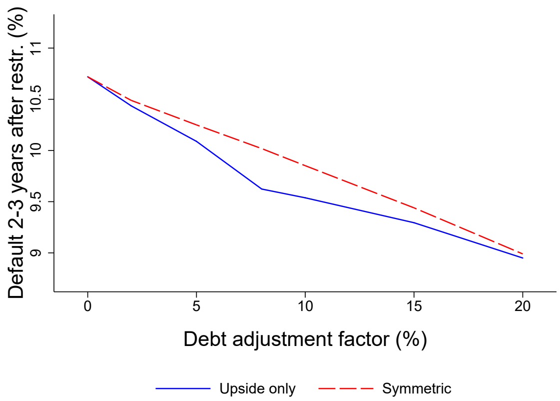
6.2 GDP-indexed bonds

The main policy-relevant question about indexed or state-contingent debt instruments (SCDIs) issued in a restructuring is whether they help reduce the incidence of default in the years following the restructuring. The COVID-19 crisis has brought further attention toward the important role of SCDIs in restructurings. IMF (2020) highlights that the pandemic led to substantial increases in sovereign debt and economic uncertainty that may lead to costly and inefficient sovereign debt restructurings involving protracted negotiations over recovery values, and potentially even relapses into default post-restructuring. The IMF work further points out that SCDIs could play an important role in improving the outcomes of these restructurings. We distinguish between two forms of indexation based on how the adoption of this instrument has evolved (see for instance Consiglio and Zenios (2018)). Specifically, we consider the implications of GDP warrants, the most frequently used early form of indexation that adjusts debt payments upwards when output growth exceeds a threshold, and we compare such indexation rule to the symmetric indexation discussed by the G20 and others. In the symmetric indexation case, debt payments adjust upwards if the economy recovers faster than expected and downwards if growth does not recover (GDP-linked bonds).

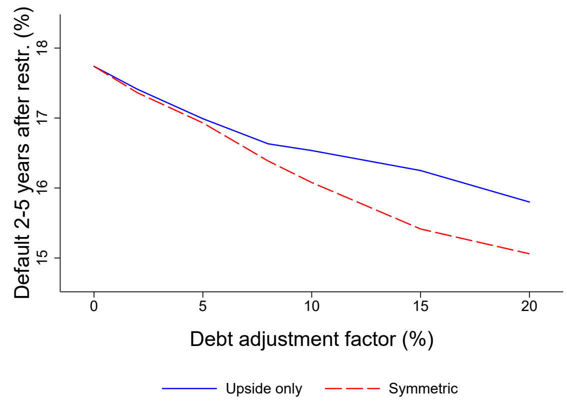
Figure 5 shows different default rates for the two parameterizations of this policy. The red dashed line represents the case in which bonds are adjusted upwards when income increases more than 3 percent and downwards when income does not grow. We refer to this case as the symmetric indexation (GDP-linked instrument) because $\Delta_H = \Delta_L > 0$. The solid blue line represents the policy in which the payments are only adjusted upward if income increases more than 3 percent. We refer to this case as upside-only indexation (GDP warrant) because $\Delta_H > 0$ and $\Delta_L = 0$. The size of the adjustment in payments is represented in the x-axis, where we consider a maximum adjustment of 20 percent ($\Delta_H = \Delta_L = 0.2$). Recall that the adjustment occurs while the country is in exclusion after restructuring, so the payments are increasing exactly by the rate shown in the x-axis.[21]

[21] Remember that during the period of exclusion after restructuring, conditional on not defaulting, the country can neither issue new debt, nor buy-back any debt. During that period, the country is limited to making the payments, which are subject to the GDP indexation in the case of the policy analyzed here.

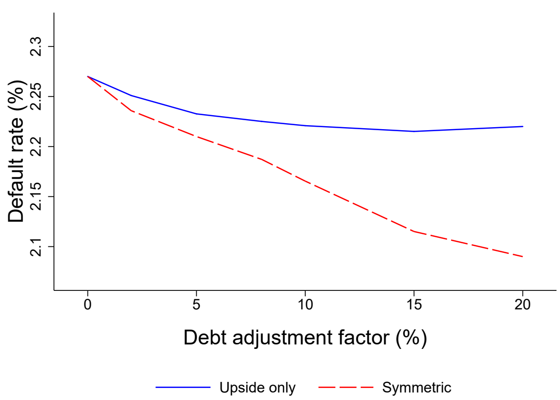
Figure 5: The Effects of GDP-Indexed Bonds on Debt, Default, and Restructuring Dynamics



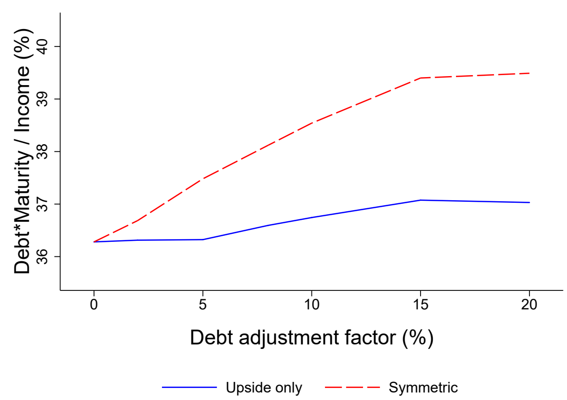
(a) Prob. of Def 2-3 Years After Restructuring



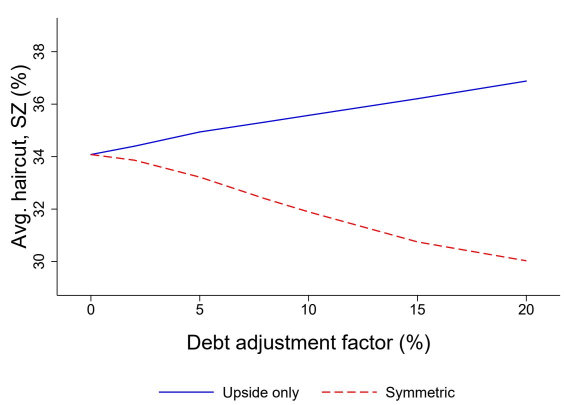
(b) Prob. of Def 2-5 Years After Restructuring



(c) Overall Default Rate



(d) Debt/Income



(e) Haircut

Note: SZ haircut refers to the haircut measure proposed by Sturzenegger and Zettelmeyer (2006) and it is defined in Appendix B.

In Figure 5, Panels (a) and (b) show the effect of both indexation schemes on default incentives in the years after the restructuring, so they inform about the use of the policy to address the highly-debated issues of restructurings doing too little to ensure debt sustainability and avoid repeated defaults. The probability of default 2 to 3 years after the restructuring, shown in panel (a), declines about 7 percent (from 10.7 to 10 percent) as the adjustment increases from 0 to 5 percent. The effects are more linear and only slightly smaller for the symmetric policy. When considering a longer post-restructuring horizon, as shown in panel (b), we find that the probability of default in the years 2 to 5 after the debt restructuring also decreases significantly for both indexation specifications, and substantially more under the symmetric case. Panels (a) and (b) also suggest that the effects of these policies are nonlinear, with the default rate declining more sharply as the symmetric adjustment increases from 0 to 20 percent. The upside-only policy shows a similar though more subtle pattern.

Panels (a) and (b) focused on the default rate for periods immediately after the restructuring. To provide a wider view of the implications of this policy, panel (c) shows the effect of the policy on the average default rate across all periods, which decreases as the debt adjustment rate increases, particularly for the symmetric specification. For instance, the default rate declines about 5 percent (from 2.27 to 2.17 percent) as the adjustment increases from 0 to 10 percent. Consistent with the lower default probability patterns shown in panel (c), as the adjustment factor increases, the sovereign is able to increase its debt-to-income ratio (panel (d)), particularly for the symmetric indexation scheme. As shown in the panel, an increase from 0 to 10 percent in the adjustment is associated to an increase in leverage of more than 6 percent (from 36.3 to 38.6 percent). Panel (e) illustrates the effect of the adjustment rate on the average SZ haircut. There are two opposing effects of the policies on haircuts. On the one hand, as pointed out by Dvorkin et al. (2021), countries that default with higher debt-to-income ratios will experience higher haircuts in a restructuring. On the other hand, as debt becomes contingent, the country is better off for any given level of haircut compared to the non-indexation scenario. The lower default rates that we document point to this gain for the country, in particular for the symmetric indexation rule. Thus, when renegotiating a debt restructuring, part of that gain is transferred to the creditors in the way of lower debt haircuts, i.e., a higher W. As shown in the plot, haircuts increase with the adjustment rate under an upside-only indexation rule, and decrease under a symmetric rule. Thus, panel (e) suggests that the debt level effect dominates the welfare effect for the upside-only indexation, so the haircut increases under such scheme, while the opposite is true under the symmetric indexation case. This intuition is confirmed by our welfare results showing that welfare gains under symmetric indexation are substantially larger than under an upside-only rule. The next section discusses the welfare effects in depth.

7 Welfare analysis

In this section, we use our quantitative framework to assess the welfare implications of the rule to distribute losses across lenders with bonds of different maturities and the use of GDP-indexed bonds upon exiting sovereign debt restructurings. We first present the methodology we employed to construct the welfare measures, and we then discuss the welfare results of the two policies.

Technically, different behavioral and market functioning assumptions in our model may justify policy interventions. For instance, lack of commitment to repay on the part of borrowers and incomplete markets with no state-contingent debt may lead to an equilibrium allocation that is not optimal. Interestingly, we find that some of those policies may be ex-ante desirable as they lead to increases in welfare (a Pareto improvement).[22] We compare welfare across different policy interventions using two alternative measures. First, we use the value function of a country with no debt and median income. Thus, the analysis can be contextualized as a country choosing the type of bond to issue from that period onward. As this hypothetical country has no debt, default is an event that may occur only in the distant future, so welfare gains or losses of restructuring may be small. Second, we compute the welfare gains of a policy change evaluated by an agent with a different discount factor than the government in charge of choosing default and borrowing decisions. This concept of welfare under disagreement was recently introduced by Aguiar et al. (2020) to evaluate the potential gains of restricting countries' access to credit markets.

As it is standard, welfare gains are measured in terms of consumption equivalent units (CE).

[22]We do not characterize the fully optimal policy, but rather focus on whether our proposed interventions lead to welfare improvements.

They represent the percent change in consumption—in every period—necessary to make an agent in the original economy indifferent with being in the economy after the policy. If gains are positive, the agent prefers to live in the economy with the policy.

7.1 Computing welfare gains from policy experiments

7.1.1 Ex-ante welfare gains with disagreement

For each alternative model, we simulate N_I paths for N_T periods starting from no debt, mean income, an normal times in international credit markets (i.e., $b = 0$, $y = 1$, $a = 0$) and a good credit record.[23]

For each path i we compute the present discounted value of the realized consumption stream from the perspective of the initial period as $\hat{V}_i(\hat{\beta}) = \sum_{t=1}^{N_T} \hat{\beta}^{t-1} u(c_{it})$, and we take the average of these present discounted values across observations of the N_{id} paths, within each model, $\bar{\hat{V}}(\hat{\beta}) = \sum_{i=1}^{N_I} \hat{V}_i(\hat{\beta})/N_I$. Given our CRRA preferences, the welfare gain from a policy is

$$gains^{exante}(\hat{\beta}) = \left(\bar{\hat{V}}(\hat{\beta})^{\text{POL}} / \bar{\hat{V}}(\hat{\beta})^{\text{BM}}\right)^{\frac{1}{1-\gamma}} - 1.$$

For the standard welfare gains, we set $\hat{\beta} = \beta$, where $\hat{\beta}$ and β are the discounts for the households and the government, respectively.[24] For the case with disagreement as in Aguiar et al. (2020), we set $\hat{\beta} \neq \beta$. In particular, we consider households that are more patient than the government, consistent with the presence of political economy features that can be associated with a lower government's discount factor, i.e., $\hat{\beta} > \beta$.

7.1.2 Welfare gains including the transition from the current state

Computing welfare gains considering the transition path is more challenging. Since the economy starts with no policy, we capture the initial stochastic steady-state using the time series simulations of our baseline economy described above. Recall that we have N_I different paths or

[23] We set $N_I = 1500$ and $N_T = 400$.

[24] For $\hat{\beta} = \beta$ we can perform this computation simply by using the value functions of the two economies, without using the simulations. We check that for $\hat{\beta} = \beta$, these two methods provide the same results.

economies i simulated for N_T periods. For each observation in good financial standing at the end of period $t > \hat{t}$,[25] the value from staying in the baseline setup (no policy) is

$$\mathcal{W}_{it}^{\text{BM}} = \frac{(c_{it})^{1-\gamma}}{1-\gamma} + \beta E_{y',a'|y_{it},a_{it}}[\mathbf{V}^{\mathbf{G}^{\text{BM}}}(y', a', b_{it+1}, m_{it+1})],$$

where the variables c_{it}, b_{it+1}, m_{it+1} denote the consumption, asset and maturity choices of a country i in the baseline simulation at period t. Similarly, the value for a country with good credit standing from switching to an economy with an alternative restructuring rule at the end of the current period is

$$\mathcal{W}_{it}^{\text{POL}} = \frac{(c_{it} - x_{it})^{1-\gamma}}{1-\gamma} + \beta E_{y',a'|y_{it},a_{it}}[\mathbf{V}^{\mathbf{G}^{\text{POL}}}(y', a', b_{it+1}, m_{it+1})],$$

where x_{it} denotes the transfers to cover the lenders's losses from implementing the switch from the baseline to the alternative policy. Thus, the gains computed here would be those that result after compensating lenders for the unexpected change in policy. The value x_{it} can be obtained as

$$x_{it} \equiv q^{\text{POL}}(y_{it}, a_{it}, b_{it+1}, m_{it+1}; m_{it+1})b_{it+1} - q^{\text{BM}}(y_{it}, a_{it}, b_{it+1}, m_{it+1}; m_{it+1})b_{it+1}.$$

Notice that if the price becomes higher after the switch, the lenders' losses are negative, and we give additional resources to the country to compute the compensated value measure. Finally, we can compute the welfare gains considering the transition to the new policy starting in good financial standing as

$$gains_{i,t}^{trans} = \left(\frac{\mathcal{W}_{it}^{\text{POL}}}{\mathcal{W}_{it}^{\text{BM}}}\right)^{\frac{1}{1-\gamma}} - 1.$$

To compute the gains considering transitions for the countries that defaulted and before restructuring, we follow a similar approach using the debt prices and expected values in default.

Finally, note that we derive the entire distribution of gains for countries with different states at the reform's onset. Following the median voter argument commonly used in the literature, we present the median gains for the whole distribution and conditional on being in default just

[25] We set the threshold $\hat{t}$ at 200, in order to have the observations in the baseline simulations after this period to follow the corresponding ergodic distribution.

before restructuring.

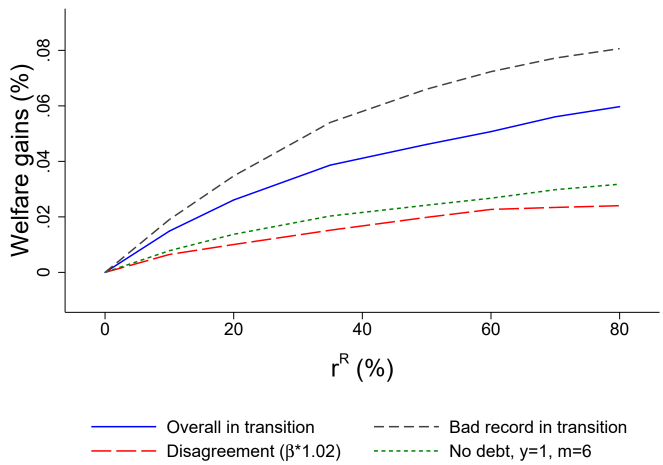
7.2 Welfare gains of the proposed restructuring policies

The effects of a rule for distributing losses across creditors on yield spreads and default rates described in subsection 5.1 suggest that it may be desirable to increase r^R, i.e., tilt the loss distribution in favor of the asset preservation of bondholders of shorter maturity instruments. Figure 6 displays the welfare changes for different values of r^R, showing that the gains are positive and monotonically increasing at decreasing marginal rates across the different economies and welfare measures.

The figure also shows that, when looking at transition gains -i.e., starting from the distribution of debt in emerging markets at the time of the policy implementation- as the value r^R is higher the welfare increases the most for a country in default that has not yet restructured its debt. In such scenario, gains are about 0.08 percent of consumption for a value of $r^R = 0.8$.[26] The median transition gains (solid blue line) are slightly lower but follow the same pattern. The green dotted line shows the gains for a country with no debt and median income. In this case, default is an event that may occur only in the distant future, so welfare gains or losses of restructuring are smaller than the gains computed in transitions. Finally, disagreement in the discount factor of households and government (dashed red line) is associated to lower, yet still positive and increasing welfare gains.

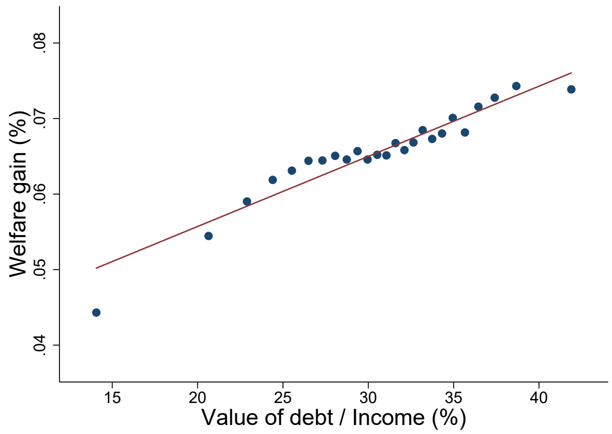
[26] Recall that these are gains after the country compensates lenders for losses implied by the reform.

Figure 6: The Effects of A Rule for Distributing Losses

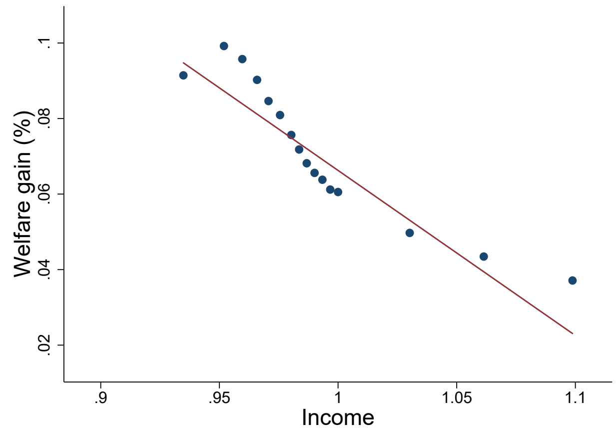


To obtain additional insight on how the welfare gains depend on the current economic conditions at the time of the policy implementation, Figure 7 illustrates the gains from implementing a $r^R = 0.8$ rule under different leverage and GDP-growth scenarios. The left panel suggests that countries with higher debt-to-income ratios at the time of the policy implementation tend to benefit more, where a 10 percentage point increase in the ratio is roughly associated to a 0.01 percentage point additional welfare gain. The right panel suggests that countries that implement the policies when GDP growth is lower benefit more, especially when growth is below trend, as the relationship seems to be nonlinear.

Figure 7: Welfare Gains of $r^R = 0.8$ Distribution Rule for Different Leverage and Income



(a) Across debt value

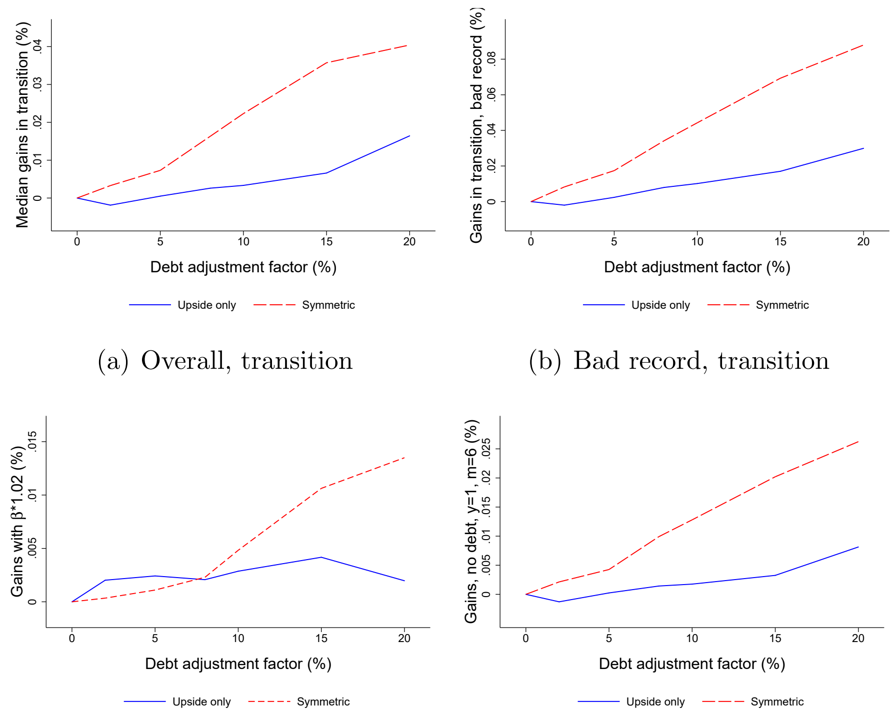


(b) Across income

Note: The figures plot the gains from applying a change in the distribution rule to $r^R = 80\%$ against various variables. We group the x-axis variables into 25 equally-populated bins. The gains are computed immediately after the announcement of the policy change, using the distributions of the baseline. Except in the first panel, the samples are restricted the countries in good record.

Our final analysis quantifies the welfare effects of allowing the borrowing country to issue GDP-indexed bonds upon exiting a debt restructuring process. We find, first, that the welfare gains —Figure 8—of this policy increase in the size of the debt adjustment associated to the indexation. As shown in all panels of the figure, this result holds for both ex-ante and transition welfare measures. Second, as also shown in all panels, the country would gain more with the symmetric adjustment (GDP-linker) than with the upside-only adjustment (GDP warrant). Third, the gains in transition are about twice as large for a country implementing the indexation policy after defaulting and prior to restructuring, i.e., with a bad record, relative to the median gains in transition (panel a). For the symmetric case, a country in default would have a gain of almost 0.1 percent of permanent consumption even after compensating lenders (panel b). Fourth, the gains in transition (panels a and b) exceed the ex-ante gains (panels c and d). Similar to the welfare result for the loss redistribution policy, ex-ante gains from indexation are small because restructuring is far into the future for a country starting with no debt and average income. Fifth, the presence of disagreement between domestic households and the government reduces the level of gains but not the shape with respect to the debt adjustment (panel c).[27]

Figure 8: Welfare Effects of GDP-Indexed Bonds with Different Debt Adjustment



(a) Overall, transition

(b) Bad record, transition

(c) With disagreement

(d) No debt, output= 1, maturity= 6

The monotonic welfare increase in the debt adjustment payment seemingly stands in contrast to Durdu (2009) who finds a threshold for the degree of GDP-indexation beyond which the policy reduces welfare because it induces a higher volatility in bond returns and thus on consumption. However, Durdu (2009) studies permanently GDP-indexed bonds in a model with sudden stops, precautionary savings and exogenous interest rates that abstracts from debt maturity, default, and restructuring, and his indexation mechanism adjusts the debt payments as a given fraction of the output shock, while our work considers a given debt payment adjustment as output growth exceeds a threshold and applies for a limited amount of time after restructuring. Our result suggests, first, that higher degrees of indexation do not necessarily lead to welfare losses, and second, that the way to model the GDP-indexation may matter considerably for welfare.

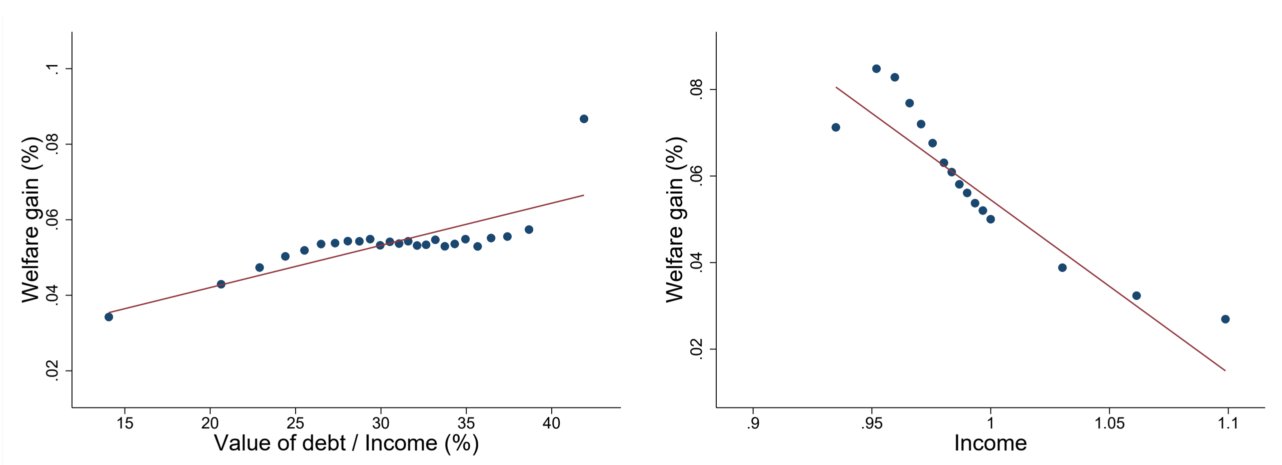
Historically, policies considering GDP-indexed bonds have garnered more attention than poli-

[27] As in the loss redistribution policy analysis, we consider a 2 percent larger discount factor for households.

cies addressing the redistribution of losses across investors holding bonds of different maturities. However, our welfare results suggest that the gains from implementing these two policies provide similar magnitude when considering a range of plausible policy parameter values and a model calibrated to an emerging market economy. Thus, our findings suggest that it may be worth lending relatively more attention to such types of redistribution policies.

Similar to the analysis for the loss distribution policy, we obtain additional insight on how the welfare gains depend on the current economic conditions at the time of the policy implementation by plotting the gains from implementing the symmetric indexation rule for different leverage and GDP-growth values (Figure 9). The left panel of the figure suggests that countries with higher debt-to-income ratios at the time of the policy announcement benefit more. The result is similar to that for the loss distribution policy, though the welfare sensitivity to the ratio under this policy is slightly lower (flatter slope). The right panel suggests that countries that announce the indexation policy when GDP growth is lower benefit more, especially when growth is below trend, as the relationship seems to be nonlinear. The welfare gain sensitivity to income for the indexation policy is also slightly lower (flatter slope) than for the loss distribution policy.

Figure 9: Welfare Gains of $\Delta_H = \Delta_L = 0.2$ Bond Indexation for Different Leverage and Income



(a) Across debt value

(b) Across income

Note: The figures plot the gains from introducing GDP-indexed bonds with symmetric change of 20% against various variables. We group the x-axis variables into 25 equally-populated bins. The gains are computed immediately after the announcement of the policy change, using the distributions of the baseline. Except the first panel, the samples are restricted the countries in good record.

8 Robustness

This section evaluates the sensitivity of the policy results to variations in key model parameters. We document that the benchmark findings for the maturity distribution policy and the bond indexation policy are robust to different assumptions regarding the economic environment. Our results for alternative values for risk aversion, the discount factor, and default costs, help validate the insights from the baseline setup for a broader set of economies. We present the summary of relevant moments for each policy in a separate table, where each column illustrates the differences between the economy without policy interventions and an alternative economy with a policy intervention and same calibration. The results for the loss redistribution policy are shown in Table 3, where the first column presents the moments for the benchmark calibration, and the second, third and fourth columns present, respectively, results for an economy with a higher coefficient of risk aversion, a higher discount factor (more patience), and lower default costs.

Table 3: Effect of a $r^R = 0.8$ Policy for Alternative Calibrations

	Benchmark calibration $\gamma = 2$ $\beta = 0.935$ $\pi = 0.90$	Higher risk aversion $\gamma = 2.5$ $\beta = 0.935$ $\pi = 0.90$	Higher patience $\gamma = 2$ $\beta = 0.945$ $\pi = 0.90$	Lower default cost $\gamma = 2$ $\beta = 0.935$ $\pi = 0.91$
Δ EMBI, p.p.	-0.49	-0.50	-0.35	-0.44
Δ EMBI (bad times), p.p.	-0.80	-0.80	-0.59	-0.71
Δ Default rate, p.p.	-0.57	-0.44	-0.50	-0.44
Δ Value of debt / Income, p.p.	0.82	0.87	-0.18	0.31
Δ Avg maturity extension, years	3.25	4.31	3.13	3.32
Δ Avg. SZ haircut, p.p.	-3.19	-3.34	-2.18	-3.77
Δ Maturity, years	-0.49	-0.66	-1.08	-0.45
Δ $\rho(n, log(y))$	0.13	0.13	0.15	0.11
Δ $10YS - 1YS$, p.p.	1.41	1.59	0.57	1.63
Δ Med welfare (transition), % CE	0.06	0.06	0.03	0.03
Δ Welfare (no debt, $y = 1$), % CE	0.03	0.03	0.02	0.02

Note: SZ haircut refers to the haircut measure proposed by Sturzenegger and Zettelmeyer (2006) and it is defined in Appendix B.

The first column suggests, as discussed earlier, that under the benchmark calibration, tilting the preservation of asset values in favor of short term creditors, i.e., $r^R = 0.8$, credit spreads decline particularly in bad times, the default rate decreases, and the country can thus support a higher debt-to-income ratio. Meanwhile, restructurings involve longer maturity extensions and lower SZ haircuts. The average maturity also falls, and the term spread increases as longer-term bonds become riskier under restructurings. Welfare gains represent about 6 basis points in consumption equivalent terms. An economy with higher risk aversion, presented in the second columns, experiences similar declines in borrowing costs but a somewhat higher average maturity extension of 4.31 years. The third column presents the results on the effects of the policy in an economy with a higher patience. In this calibration, the policy induces a more moderate decline in credit spreads relative to the other two economies discussed above. At the same time, there is a larger decline in the size of the SZ haircut and the term spread increases by less. Finally, the lower default cost, presented in the fourth column, leads to similar statistics as those for the benchmark calibration.

Table 4 provides additional robustness insights similar to Table 3 but focusing on the effects of the symmetric bond indexation policy. Under the benchmark calibration, the bond indexation allows for a noticeable increase in the debt-to-income ratio, while reducing the average maturity extension and particularly the SZ haircut in restructurings. The policy also reduces the probability that the country defaults again immediately after restructuring, and leads to welfare gains that are comparable to those of the other policy. The economy with higher risk aversion exhibits similar change patterns, with a slightly more moderate increase in leverage, and a bit larger decline in maturity extensions and in the average SZ haircut during restructurings. Similarly, the probability of defaulting immediately after the restructuring falls only slightly more compared to the benchmark calibration. Welfare gains of the transition, as expected, are slightly larger compared to the benchmark calibration, as the country values more the insurance provided by the contingency of the bond payments. In an economy with more patience, the policy leads to slightly larger declines in maturity extensions and SZ haircuts than the benchmark and high risk aversion calibrations. The probability of default post-restructuring declines a bit more strongly as well. Finally, the effects of the policy in an economy with a lower default cost are also similar to those of the benchmark calibration. Overall, our results for different calibrations suggest that our benchmark findings are applicable to the debt restructurings of a broad range of economies.

Table 4: Effect of a $\Delta_H = \Delta_L = 0.2$ Bond Indexation Policy for Alternative Calibrations

	Benchmark calibration $\gamma = 2$ $\beta = 0.935$ $\pi = 0.90$	Higher risk aversion $\gamma = 2.5$ $\beta = 0.935$ $\pi = 0.90$	Higher patience $\gamma = 2$ $\beta = 0.945$ $\pi = 0.90$	Lower default cost $\gamma = 2$ $\beta = 0.935$ $\pi = 0.91$
Δ EMBI, p.p.	0.02	0.04	0.02	0.04
Δ EMBI (bad times), p.p.	0.02	0.01	0.03	0.08
Δ Default rate, p.p.	-0.18	-0.17	-0.11	-0.15
Δ Value of debt / Income, p.p.	2.52	2.40	2.53	2.37
Δ Avg maturity extension, years	-0.77	-0.94	-0.54	-0.53
Δ Avg. SZ haircut, p.p.	-4.04	-4.35	-4.87	-3.15
Δ Def pr. 2 or 3yr after restruct, p.p.	-1.73	-1.88	-2.04	-2.07
Δ Def pr. 2,3,4 or 5yr after restruct, p.p.	-2.68	-3.01	-3.43	-3.18
Δ Med welfare (transition), % CE	0.04	0.07	0.04	0.05
Δ Welfare (no debt, $y = 1$), % CE	0.03	0.03	0.02	0.04

Note: SZ haircut refers to the haircut measure proposed by Sturzenegger and Zettelmeyer (2006) and it is defined in Appendix B.

9 Impact of the joint implementation of the policies

This section compares the effects of separately implementing each of the policies discussed earlier and implementing them jointly. Table 5 presents the impact on the common moments from the prior result tables. The table shows that the policies exhibit complementarity for some of the moments. As shown in the third column, the introduction of both policies leads to lower EMBI spreads, which decline almost one percentage point in bad times. Consistent with the average effect on spreads, the default rate also declines noticeably. Both the default rate and the EMBI spread fall more compared to their decline under either of the policies implemented separately, which are shown in the first columns. The large drop in the default rate occurs even sustaining the level of borrowing. The change in leverage from the joint implementation of the policies, while positive, is slightly lower compared to the case of the indexation-only case, suggesting some minor crowding out between the two policies in this dimension. When looking at the effects of the joint policy implementation on restructurings, they display "healthy" features: larger maturity extensions (2 years) and significantly smaller haircuts (8 percentage points). Finally, all the metrics for welfare suggest an improvement, especially for countries that have defaulted but have not yet restructured their debt, where the gain is almost 20 basis points in equivalent consumption. The welfare gains of the joint implementation with disagreement are positive, and compared to the individual policies, the effect is between two and five times larger.

Table 5: Effect of both policies at $r^R = 0.8$ and $\Delta_H = \Delta_L = 0.2$

	Only redistribution, $r^R = 0.8$	Only contingent debt, $\Delta_H = \Delta_L = 0.2$	Both redistribution & contingent debt
Δ EMBI, p.p.	-0.49	0.02	-0.53
Δ EMBI (bad times), p.p.	-0.80	0.02	-0.87
Δ Default rate, p.p.	-0.57	-0.18	-0.79
Δ Value of debt / Income, p.p.	0.82	2.52	2.40
Δ Avg maturity extension, years	3.25	-0.77	1.95
Δ Avg. SZ haircut, p.p.	-3.19	-4.04	-7.90
Δ Med welfare (transition), % CE	0.06	0.04	0.10
Δ Welfare (no debt, $y = 1$), % CE	0.03	0.03	0.07
Δ Med welfare, (bad record, transition) % CE	0.08	0.09	0.18
Δ Welfare with disagreement ($\beta * 1.01^2$), % CE	0.02	0.01	0.05

Note: SZ haircut refers to the haircut measure proposed by Sturzenegger and Zettelmeyer (2006) and it is defined in Appendix B.

10 Conclusion

Our work provides a micro-founded framework to discuss the implications of policy interventions for sovereign debt restructuring outcomes.

We consider a policy addressing asset preservation across creditors holding bonds of different maturities. We find that a rule that tilts the distribution of creditor losses during restructurings toward holders of long-maturity bonds may be desirable for a wide set of economies. This policy lowers short-term yield spreads and debt maturity especially in bad times, reducing overall portfolio borrowing costs and the associated default probability of the sovereign during periods of elevated credit market stress. As the policy leads countries to experience default holding shorter-term maturities, the associated restructurings rely more heavily on maturity extensions and less on face value haircuts.

We also consider the use of GDP-indexed bonds during restructurings. They help remedy the lack of market access experienced by troubled borrowers and significantly reduce the probability of repeated restructurings. Our results also suggest that symmetric GDP indexation rules deliver larger welfare gains than upside-only rules. Moreover, the welfare effects are much larger for a country about to restructure its debt and are reduced when controlling for debt accumulation biases specific to models in the quantitative sovereign default literature.

While policies involving GDP indexation have received more attention than loss-redistribution policies in restructuring discussions, we also find that the welfare gains of the two policies are of similar magnitude, suggesting that it may be worth lending more attention to cross-creditor loss-redistribution policies. Finally, we document that when implemented together, the two policies complement and reinforce each other along most dimensions of debt, default, and welfare metrics considered in the analysis, suggesting benefits from their joint implementation.

References

Abbas, S. A., Pienkowski, A., and Rogoff, K. (2019). *Sovereign debt: A guide for economists and practitioners*. Oxford University Press.

Aguiar, M., Amador, M., and Fourakis, S. (2020). On the Welfare Losses from External Sovereign Borrowing. *IMF Econ Rev*, 68:163–194.

Aguiar, M. and Gopinath, G. (2006). Defaultable debt, interest rates and the current account. *Journal of International Economics*, 69:64–83.

Alfaro, L. and Kanczuk, F. (2006). Sovereign debt: Indexation and maturity. Working Paper 560, Inter-American Development Bank.

Arellano, C. (2008). Default risk and income fluctuations in emerging economies. *American Economic Review*, 98(3):690–712.

Arellano, C., Mateos-Planas, X., and Rios-Rull, J.-V. (2019). Partial default. *Manuscript, University of Minnesota*.

Arellano, C. and Ramanarayanan, A. (2012). Default and the maturity structure in sovereign bonds. *Journal of Political Economy*, 120(2):187 – 232.

Asonuma, T. and Joo, H. (2020). Sovereign debt restructurings: Delays in renegotiations and risk averse creditors. *Journal of the European Economic Association*, 18:2394 – 2440.

Asonuma, T. and Trebesch, C. (2016). Sovereign Debt Restructurings: Preemptive Or Post-Default. *Journal of the European Economic Association*, 14(1):175–214.

Asonuma, T., Trebesch, C., and Ranciere, R. (2015). Sovereign debt restructuring and the short-term debt curse. *Manuscript, IMF and Paris School of Economics*.

Barbieri Hermitte, R. (2020). Gdp-linked bonds: A proposal worth looking into. In Paganetto, L., editor, *Capitalism, Global Change and Sustainable Development*, pages 79–86, Cham. Springer International Publishing.

Barr, D., Bush, O., and Pienkowski, A. (2014). GDP-linked bonds and sovereign default. Bank of England working papers 484, Bank of England.

Bianchi, J. (2016). Efficient Bailouts? *American Economic Review*, 106(12):3607–3659.

Borensztein, E. and Mauro, P. (2002). Reviving the case for gdp-indexed bonds. IMF Policy Discussion Paper 02/10, IMF.

Comelli, F. (2015). Estimation and out-of-sample prediction of sudden stops: Do regions of emerging markets behave differently from each other? Working paper 15/138, International Monetary Fund.

Consiglio, A. and Zenios, S. A. (2018). Pricing and hedging gdp-linked bonds in incomplete markets. *Journal of Economic Dynamics and Control*, 88:137–155.

Cruces, J. J. and Trebesch, C. (2013). Sovereign Defaults: The Price of Haircuts. *American Economic Journal: Macroeconomics*, 5(3):85–117.

Drèze, J. (2000). Economic and social security in the twenty-first century, with attention to europe. *Scandinavian Journal of Economics*, 102(3):327–348.

Durdu, C. B. (2009). Quantitative implications of indexed bonds in small open economies. *Journal of Economic Dynamics and control*, 33(4):883–902.

Dvorkin, M., Sánchez, J. M., Sapriza, H., and Yurdagul, E. (2021). Sovereign debt restructurings. *American Economic Journal: Macroeconomics*, 13(2):26–77.

Eaton, J. and Gersovitz, M. (1981). Debt with potential repudiation: theoretical and empirical analysis. *Review of Economic Studies*, 48:289–309.

Erce, A. (2013). Sovereign debt restructurings and the IMF: implications for future official interventions. Globalization Institute Working Papers 143, Federal Reserve Bank of Dallas.

Fernandez, R. and Martin, A. (2014). The long and the short of it: Sovereign debt crises and debt maturity. Economics Working Papers 1459, Department of Economics and Business, Universitat Pompeu Fabra.

Froot, K. A., Scharfstein, D. S., and Stein, J. C. (1989). Ldc debt: Forgiveness, indexation, and investment incentives. *The Journal of Finance*, 44(5):1335–1350.

Guzman, M., Ocampo, J. A., and Stiglitz, J. E. (2016). *Too Little, Too Late: The Quest to Resolve Sovereign Debt Crises*. Columbia University Press.

Hatchondo, J. C. and Martinez, L. (2009). Long-duration bonds and sovereign defaults. *Journal of International Economics*, 79:117–125.

Hatchondo, J. C. and Martinez, L. (2012). On the benefits of GDP-indexed government debt: lessons from a model of sovereign defaults. *Economic Quarterly*, 98(2Q):139–157.

IMF (2002). *A new approach to sovereign debt restructuring*. International Monetary Fund, Publication Services, ISBN 1-58906-121-7.

IMF (2003a). Communiqué of the international monetary and financial committee of the board of governors of the international monetary fund. Communiqué, IMF.

IMF (2003b). The restructuring of sovereign debt: Assessing the benefits, risks, and feasibility of aggregating claims. Technical report, IMF.

IMF (2013a). Sovereign debt restructuring-recent developments and implications for the fund's legal and policy framework. Public Information Notice 13/61, IMF.

IMF (2013b). Sovereign debt restructurings: Recent developments and implications for the fund's legal and policy framework. Policy paper, IMF.

IMF (2014). The fund's lending framework and sovereign debt - preliminary considerations. Staff reports, International Monetary Fund.

IMF (2017). State contingent debt instruments for sovereigns. Policy Paper 17/187, IMF.

IMF (2020). The role of state-contingent debt instruments in sovereign debt restructurings. *International Monetary Fund Staff Discussion Notes*, 2020(006).

Krugman, P. (1988). Financing vs. forgiving a debt overhang. *Journal of Development Economics*, 29:253–268.

Mihalache, G. (2020). Sovereign default resolution through maturity extension. *Journal of International Economics*, 25.

Roch, F. and Roldán, F. (2021). Uncertainty Premia, Sovereign Default Risk, and State-Contingent Debt. IMF Working Papers 2021/076, International Monetary Fund.

Roch, F. and Uhlig, H. (2016). The Dynamics of Sovereign Debt Crises and Bailouts. IMF Working Papers 16/136, International Monetary Fund.

Sánchez, J. M., Sapriza, H., and Yurdagul, E. (2018). Sovereign default and maturity choice. *Journal of Monetary Economics*, 95:72–85.

Sandleris, G., Sapriza, H., and Taddei, F. (2009). Indexed sovereign debt: An applied framework. *Universidad Torcuato Di Tella Working Paper 01/2009*.

Shiller, R. J. (1993). *Macro Markets: Creating Institutions for Managing Society's Largest Economic Risks*. Oxford University Press.

Sturzenegger, F. and Zettelmeyer, J. (2006). Has the legal threat to sovereign debt restructuring become real? Unpublished manuscript, Universidad Torcuato Di Tella.

Tauchen, G. (1986). Finite state markov-chain approximations to univariate and vector autoregressions. *Economic Letters*, 20:177–181.

UNCTAD (2015). Sovereign debt workouts - roadmap and guide. United nations conference on trade and development, United Nations.

Yue, V. Z. (2010). Sovereign default and debt renegotiation. *Journal of International Economics*, 80(2):176–187.

Zettelmeyer, J., Trebesch, C., and Gulati, M. (2013). The greek debt restructuring: An autopsy. *Economy Policy*, 28(75):513–563.

Appendix A Data details

Our data moments are taken from the Dvorkin et al. (2021), which also explains the computation of these variables, including the sources and variable names. For the sake of completeness, we also include here a brief data description.

- Output measure is the GDP per capita (constant 2010 US$) from World Development Indicators (WDI).
- Consumption is the households' final consumption expenditure per capita (constant 2010 US$), from the WDI. The second order moments of consumption and output are obtained after H.P. filtering the data for the entire horizon with available data.
- The maturity data for Colombia and Brazil are from country-specific sources, "Ministerio de Hacienda y Credito Publico" and "Secretaria de Tesouro Nacioal", respectively. For Chile and Mexico, the source for maturity is the OECD.
- Duration measures follow the Macaulay definition as is standard in the literature. For Chile and Colombia, such measure is available in the same sources as the maturity. The measures for Brazil and Mexico are our own computations using the aforementioned maturity data and the average interest rate data from the International Debt Statistics.
- Spreads: The yield spreads are obtained by subtracting U.S. yields from U.S. dollar sovereign yields for Brazil, Colombia, and Mexico. Monthly zero-coupon one- and ten-year U.S. dollar sovereign yields are obtained from the Bloomberg database. The yearly yields are the medians over months each year. The spreads are then obtained by subtracting one- and ten-year U.S. These latter variables are from the FRED database.

Appendix B Computational Details

B.1 Basics

We solve the model numerically with value function iteration on a discretized grid for debt and output. We use a different debt grid for each maturity m, evenly spaced between 0 and $0.7q^*(m;r^R)$, where $q^*(m;r^R)$ is the risk-free price for a bond of maturity m. We use 121 points for the debt grid and 51 points for the output. We solve the policy and value functions for all points on these grids. The price function is solved for 41 equally-spaced points on this grid, and the implied function is linearly interpolated in the other parts of the algorithm. Since the steeper regions of the price function is where default usually happens, we have an uneven grid for income that is finer below the median income. In particular, the income grid is spread evenly below the median income over 45 points and evenly above the median income grid over 5 points. We use the Tauchen (1986) method to discretize the income process.

In solving the model, we introduce taste shocks to the government's value to facilitate the model solution. In particular, the government draws a vector of taste shocks each period and each component of this vector shifts the value obtained by a different discrete decision. (This means a vector with $J = M \times N + 1$ components, where N is the number of possible debt choices, and M is the maximum maturity allowed. One additional component corresponds to the default/restructuring decision.) We follow Dvorkin et al. (2021) in assuming that these shocks follow Generalized Extreme Value Distribution, and also in setting the parameters governing the distribution. This approach introduces sufficient randomness into the government's decision to convexify its problem, hence smooth out its value and price functions, and allows convergence of the model solution.

We solve for the lenders' offer, $W^L(y,b,m)$, through a discrete search over 501 points on a state-specific evenly-spaced W-grid. The lowest point on the grid is 0 and the highest is $\min[0.7, -b \times m]$. Since the borrowers' offer $W^S(y,b,m)$ is equal to $-b\, q^D(y,b,m;m)$ it is not necessary to follow the same discrete search as W^L for W^S.

For convergence, we use a measure of distance for the price function of debt in good standing in a given iteration that considers the maximum absolute distance of the prices across two iterations relative to the price level in a given state. We declare convergence when this error is lower than 10^{-4}. We update the lenders' offer only when this error is $< 10^{-3}$.

We first solve the model (value, policy and price functions). Then we simulate 1500 paths for 400 years, and compute our moments after dropping the first 100 years in each path. In computing the model moments, we first obtain the means, correlations and standard deviations for each path, and then take averages over paths.

B.2 Computing spreads, duration and haircuts

Spreads. Consider a country with income y, debt rollover shock a, and a debt portfolio choice with maturity m and level b. The yield for a bond with maturity n in our model is

$$YTM(y, a, b, m; n) \equiv \left(\frac{1}{q(y, a, b, m; n) - q(y, a, b, m; n-1)} \right)^{\frac{1}{n}} - 1.$$

We use this yield-to-maturity measure to compute the $n-$year spread for a country with a portfolio of maturity m as $YTM(y, a, b, m; n) - r$.

On the other hand, the EMBI+ in our model is computed as:

$$\text{EMBI} = \tilde{r} - r$$

where $\tilde{r}$ is the uniform discount rate that would correspond to the unit price of the chosen portfolio:

$$\sum_{t=1}^{n} \left(\frac{1}{1+\tilde{r}} \right)^{t} = q(y, a, b, m; n). \tag{1}$$

Duration and maturity. We use the following definition for the duration of a bond as a weighted sum of future promised payments, which is consistent with the definitions of the variables we use for the data:

$$\text{Duration} = \frac{\sum_{t=1}^{m'} t \times \left(\frac{1}{1+\tilde{r}}\right)^t}{\sum_{t=1}^{m} \left(\frac{1}{1+\tilde{r}}\right)^t}$$

where $\tilde{r}$ is the discount rate for the new portfolio given in (1). For maturity, we simply use the maturity of the new portfolio, m'.

Haircuts. We use the haircut measure proposed by Sturzenegger and Zettelmeyer (2006), H_{SZ} together with a measure of face-value haircut. The face value haircut is simply equal to one minus the ratio of the face value of the new debt relative to the face value of the old (defaulted) debt. The SZ haircut is defined as,

$$H_{SZ} = 1 - \frac{\text{Present Value of New Debt}}{\text{Present Value of Old Debt}},$$

where the present value of the cash flows is discounted using a fixed interest rate of 10%.