# Inelastic Demand Meets Optimal Supply of Risky Sovereign Bonds*

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**Abstract**

We present evidence of inelastic demand for risky sovereign bonds and explore its implications for optimal government debt policies. Using monthly changes in the composition of a major international bond index, we identify flow shocks unrelated to fundamentals that shift the available bond supply. From these shocks, we estimate an inverse demand elasticity of -0.30 and show that it increases with countries' default risk. We formulate a sovereign debt model with endogenous default and inelastic investors, calibrated to our empirical estimates. By penalizing additional borrowing, an inelastic demand acts as a disciplining device that reduces default risk and bond spreads.

**Keywords:** inelastic financial markets, institutional investors, international capital markets, sovereign debt

**JEL Codes:** F34, F41, G11, G15

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# 1 Introduction

Governments in emerging economies heavily depend on bonds issued in liquid international capital markets for their overall financing. The behavior of investors in these markets is thus crucial to understanding governments' borrowing costs, default risk, and optimal debt management. Standard sovereign debt models often assume that investor demand is perfectly elastic, implying that investors are willing to lend any amount governments request at the risk-free rate plus a default-risk premium. This assumption on investor behavior contrasts with a body of recent work for other asset markets that allows for a richer demand structure, typically involving an inelastic or downward-sloping demand (Koijen and Yogo, 2019; Gabaix and Koijen, 2021; Vayanos and Vila, 2021; Gourinchas et al., 2022; Greenwood et al., 2023).

This paper presents novel evidence of downward-sloping demand curves in risky sovereign bond markets and analyzes their impact on governments' optimal debt policies. We first estimate high-frequency bond price reactions to shocks to passive investors' demand, unrelated to fundamentals. These shocks come from monthly variations in the composition of the largest benchmark index for U.S. dollar-denominated bonds from emerging economies, the J.P. Morgan Emerging Markets Bond Index Global Diversified (EMBIGD). Changes in this index affect the demand of passive investors that seek to replicate its composition and imply a shift in the supply of bonds available to active investors. We find that bond prices significantly react to these shocks. Our estimates imply an inverse price demand elasticity of $-0.30$, which we call a reduced-form elasticity.

We then formulate a quantitative sovereign debt model that features endogenous bond issuances and default risk, and discipline it based on our reduced-form estimates. The goal of the model is twofold. First, we use it to isolate the part of the estimated reduced-form elasticity explained by endogenous responses in government debt policy and future bond payoffs, allowing us to identify a structural elasticity. Our findings show that these endogenous forces explain over one-third of the reduced-form elasticity. Second, we analyze the aggregate implications of a downward-sloping demand in risky sovereign debt markets. In the presence of inelastic investors, an additional unit of debt reduces bond prices even if default risk is constant, which increases governments' borrowing costs. Since governments internalize this effect, an inelastic demand limits debt issuances and acts as a disciplining device. Using our calibrated model, we show that this channel significantly reduces default risk and bond spreads.

To guide our empirical analysis, we start from a simple framework where investors are heterogeneous in their degree of activism (or passivism), i.e., in how they allocate their funds across risky assets. We define passive demand as the portion of investors' holdings aimed at replicating the index composition they follow. The passive demand is perfectly inelastic and shifts with changes in index weights. For any asset in fixed supply, a higher passive demand implies a leftward shift in the "effective supply," the quantity of bonds available to active investors. If this shift is unrelated to country fundamentals, and assuming that future asset payoffs remain fixed, this variation can be used to examine whether active investors' demand curves slope downward and to measure their demand elasticity (Pandolfi and Williams, 2019; Pavlova and Sikorskaya, 2022). Nevertheless, if expected payoffs endogenously respond to changes in the effective supply, any observed price variation resulting from the shift could over or underestimate the demand elasticity. Since asset prices and payoffs are jointly determined, this potential response motivates the need for a structural model in which prices, the bond supply, and expected payoffs are endogenous outcomes.

On the empirical front, we identify shifts in a country's effective supply of sovereign bonds by exploiting monthly rebalancings in the EMBIGD. We derive a measure of the flows implied by the rebalancings (FIR), combining the assets passively tracking the EMBIGD with the index's monthly changes. These frequent rebalancings occur because qualifying new bond issuances are incorporated into the EMBIGD, while maturing bonds are removed. These adjustments alter country weights in the index, triggering similar rebalancings in the portfolios of passive investors replicating it to minimize potential tracking error costs. Our FIR measure takes advantage of these rebalancings and measures the consequent shifts in the available bond supply to active investors. Intuitively, a 1 p.p. FIR implies a 1% reduction in the supply of the country's bonds available to active investors at the time of the rebalancing.

While the FIR reflects changes in the available bond supply, it may be influenced by country fundamentals and other factors that affect bond prices. First, when a country issues new bonds that are added to the index or retires existing ones, its weight changes, and so does its FIR. Second, even for countries with a constant amount of debt outstanding, changes in bond prices are still mechanically correlated with the FIR, since index weights depend on bond prices. Because issuances or retirements, as well as changes in bond prices, can be correlated with a country's fundamentals (e.g. changes in sovereign risk), we cannot directly use the FIR to estimate the price demand elasticity.

To address these issues, we focus on each rebalancing date only on countries that do not experience changes in the face amount of outstanding index bonds and construct an instrument for the FIR that exploits the specific weighting scheme of the EMBIGD. Our instrument consists of the percentage change in countries' *synthetic* index weights, which we compute based on their eligible bonds' face value rather than market value and, therefore, do not mechanically correlate with bond prices. Since we focus on countries with constant debt outstanding, the variation in our instrument comes from other countries' bond issuances or retirements. Importantly, this variation depends on a diversification rule of the EMBIGD that imposes caps on country weights based on the face amount of their outstanding bonds. When countries in the EMBIGD issue or retire bonds, the *synthetic* weights of other countries in the index are affected according to how much those changes impact the cap on their weights, leading to varying bond inflows or outflows. We then combine our instrument with the specific timing of the rebalancings, which become effective on the last business day of each month, to analyze how bond prices react to FIR shocks in small time windows around the rebalancing dates.

Our analysis reveals that a higher FIR leads to higher bond prices. On average, a 1 percentage point (p.p.) increase in the FIR corresponds to a 30 basis point increase in bond prices. These estimates imply a reduced-form inverse demand elasticity of $-0.30$. We find that these price reactions vary across countries with different levels of default risk. For countries with higher default risk, a 1 p.p. change in FIR results in up to a 41 basis point increase in bond prices. In contrast, for safer countries, the estimates are smaller (an 11 basis point increase) and statistically not significant. Overall, these findings suggest that investors demand a premium as compensation for holding risky bonds (in excess of their default risk), which gives rise to an inconvenience yield.

On the quantitative front, we formulate a sovereign debt model where the government has limited commitment and can endogenously default on its debt obligations. Standard models of this nature typically assume a perfectly elastic demand for sovereign bonds, with changes in bond prices driven solely by variations in default risk (Arellano, 2008; Chatterjee and Eyigungor, 2012). We extend these models using a richer demand structure that includes both active and passive investors and a downward-sloping demand curve for active investors that is modeled following Gabaix and Koijen (2021). Specifically, we assume that active investors have a mandate that determines how they should allocate their funds. They can deviate from that mandate based on bonds' expected returns but are limited in the extent to which they can do so. To create a tight link with our empirical analysis, we introduce secondary markets where bonds are traded. By shocking the passive demand, we can replicate our empirical reduced-form elasticity within the model.

We use the calibrated model to decompose the estimated reduced-form elasticity into two components: the downward-sloping part of the demand curve (i.e., the structural elasticity) and the endogenous changes in expected future bond payoffs, which are influenced by how government issuances respond to the FIR shock. We find that changes in future bond payoffs account for one-third of the reduced-form elasticity. Their impact grows as the persistence of the shock increases.

Overall, our results underscore the importance of accounting for issuers' endogenous responses and changes in the expected asset repayment. These factors alleviate potential biases in estimating demand elasticities. Our FIR measure is inherently more temporary than other instruments used in the literature, such as index additions or deletions or index methodological recompositions. Still, we find that endogenous changes in expected bond repayments can account for about one-third of the total price response.

Our model also allows us to examine the implications of a downward-sloping demand curve on the optimal government debt and default policies. In the presence of inelastic demand, we observe lower default risk and higher bond prices for similar debt levels compared to a scenario with perfectly elastic demand. This outcome is not driven by a convenience yield (i.e., a higher price that investors are willing to pay for the bond) but rather by the inelastic demand serving as a disciplining device for the government. The underlying mechanism is as follows: with a downward-sloping demand, issuing an additional unit of debt decreases bond prices even if default risk remains fixed. As a result, the government finds that issuing large amounts of debt is too costly, thus limiting the maximum amount of debt it is willing to issue. In our quantitative analysis, we find that this limit leads to a substantial reduction in default risk of around 25%, which lowers bond spreads and the government's borrowing costs. On the other hand, we show that an inelastic demand leads to a debt policy that is less responsive to shocks. On balance, we find that the benefits derived from the disciplining device dominate, and the government is better off in the presence of inelastic investors.

Our findings contribute to various strands of literature. First, we contribute to a long-standing literature using index rebalancings to estimate asset price reactions, demand elasticities, and changes in investors' portfolios across different asset classes (Harris and Gurel, 1986; Shleifer, 1986; Greenwood, 2005; Hau et al., 2010; Chang et al., 2014; Raddatz et al., 2017; Pandolfi and Williams, 2019; Pavlova and Sikorskaya, 2022; Beltran and Chang, 2024).[1] Our contribution lies in showing that demand curves slope downward in one of the most relevant markets for government financing in emerging economies: the international

[1] Beyond index rebalancings, Ray, Droste, and Gorodnichenko (2024) use high-frequency U.S. Treasury auctions to estimate the effect of demand shocks on Treasury yields. Monteiro (2024) uses auction data for Portuguese sovereign bonds.

U.S. dollar bond market.

An important contribution of our work is showing that, even in response to exogenous supply-shifting shocks, part of the price movement can be attributed to changes in assets' expected payoffs rather than solely reflecting an inelastic demand component. Our analysis can be applied to any asset, beyond sovereign bonds, whose future cash flows or payoffs are affected by movements in the effective supply. As such, it can be extended to a vast literature that uses exogenous shifts in the effective supply as an instrument to estimate demand elasticities. Typical examples are sovereign and corporate bonds and equities from both developed and emerging economies.

Second, a growing literature on inelastic financial markets emphasizes the role of the demand side in explaining asset prices across various financial markets (Koijen and Yogo, 2019; Gabaix and Koijen, 2021; Vayanos and Vila, 2021). Taking as given expected asset payoffs, this literature analyzes how an inelastic demand affects the pricing of risk-free U.S. Treasuries (Krishnamurthy and Vissing-Jorgensen, 2012; Greenwood et al., 2015; Mian et al., 2022; Jiang et al., 2024) and international financial assets (Koijen and Yogo, 2020; Gourinchas et al., 2022; Greenwood et al., 2023).[2] Similar to our study, Choi, Kirpalani, and Perez (2024) analyze the effects of a downward-sloping demand on the optimal issuance of safe government bonds. In contrast, we focus on the interplay between a downward-sloping demand curve, default risk, and the provision of risky bonds.[3] We show that the demand elasticity interacts with default risk and influences a government's supply of risky bonds.

Third, our study also connects to a body of work examining how changes in the investor base of government debt impact bond yields (Warnock and Warnock, 2009; Dell'Erba et al., 2013; Peiris, 2013; Arslanalp and Poghosyan, 2016; Ahmed and Rebucci, 2024). In related work, Fang et al. (2022) develop a demand system to quantify how changes in the composition of investors (domestic versus foreign, banks versus non-banks) affect government bond yields in international markets. Zhou (2024) focuses on emerging market sovereign debt and shows that differences in a country's foreign investor base can help explain the heterogeneous influence of the global financial cycle. In this paper, we exploit exogenous changes in the composition of the investor base (passive versus active funds) to provide evidence of downward-sloping demand curves for risky sovereign bonds.

[2] A related literature focuses on U.S. and international corporate bond markets (Dathan and Davydenko, 2020; Bretscher et al., 2022; Calomiris et al., 2022; Kubitza, 2023).

[3] Kaldorf and Rottger (2023) analyze the implications of convenience yields on the pricing and optimal supply of risky sovereign bonds. In their setup, and similarly to Choi et al. (2024), investors are willing to pay a higher price for holding risky sovereign bonds due to their collateral services. In contrast, based on our empirical results, our model assumes that investors demand a premium (an inconvenience yield) for holding risky bonds.

Fourth, our paper relates to a large literature on quantitative sovereign debt models (Aguiar and Gopinath, 2006; Arellano, 2008; Chatterjee and Eyigungor, 2012). Our framework extends standard models by introducing a downward-sloping demand for bonds, different investor types (active and passive), and secondary bond markets, which creates a tight link with our empirical analysis and allows us to discipline the model based on our reduced-form estimates.[4] Using this setup, we show that an inelastic demand serves as a disciplining device that lowers default risk. In this regard, our paper connects to a broader literature on the use of fiscal rules as commitment devices (Alfaro and Kanczuk, 2017; Dovis and Kirpalani, 2020; Hatchondo et al., 2022; Bianchi et al., 2023). We show that if the demand for bonds is inelastic, the market by itself can create incentives that discourage borrowing and decrease default risk.

In our analysis, we are agnostic about the mechanisms behind the downward-sloping demand. Previous work by Borri and Verdelhan (2010), Lizarazo (2013), Pouzo and Presno (2016), and Arellano et al. (2017) analyzes sovereign debt models with risk-averse investors. In these models, investors are inelastic because they must be compensated for each additional unit of risky debt they hold. There are several other mechanisms that can explain a downward-sloping demand. For example, it can be driven by regulatory limitations such as a Value-at-Risk (VaR) constraint (Gabaix and Maggiori, 2015; Miranda-Agrippino and Rey, 2020), by liquidity considerations (He and Milbradt, 2014; Moretti, 2020; Passadore and Xu, 2022; Chaumont, 2024), by investors' buy-and-hold strategies, or by fixed-share mandates specifying how investors should allocate their funds across assets (as in Gabaix and Koijen, 2021). Our setup relies on a flexible demand structure that can accommodate any of these potential drivers. Our aim is not to uncover the causes of investors' inelastic behavior but to examine its aggregate implications.

The rest of the paper is structured as follows. Section 2 introduces a simple framework to guide our analysis. Section 3 presents the empirical analysis, including details on the institutional setup of the EMBIGD index, data sources, identification strategy, and results. Section 4 formulates a sovereign debt model with endogenous default and inelastic investors, and Section 5 presents the quantitative analysis. Section 6 concludes.

[4] Our paper is related to recent work by Costain et al. (2022), who introduce endogenous default risk into a Vayanos-Vila preferred habitat model to analyze the term structure of interest rates in the European Monetary Union.

## 2 Index Rebalancings as Passive Demand Shocks

We present a simple framework to guide our empirical analysis. The setup builds on Pavlova and Sikorskaya (2022) and illustrates how one can use index rebalancings to identify changes in the passive demand that shift the (effective) bond supply available to active investors. These shifts can then be used to estimate reduced-form price demand elasticities. Although we focus on the case of sovereign bonds, the same methodology can be applied to any asset (e.g., equities).

Consider a bond $i$ that is part of a benchmark index $\mathcal{I}$. Investors are heterogeneous in their degree of activism or passivism. That is, they track the composition of the $\mathcal{I}$ index but differ in how actively or passively they do so.[5] Let $\boldsymbol{w}_t = \left\{w_t^1, ..., w_t^N\right\}$ denote the vector of time-varying index weights for each constituent bond of $\mathcal{I}$. We define the passive demand, $\mathcal{T}_t^i(w_t^i)$, as the portion of investors' holdings aimed at replicating the composition of the $\mathcal{I}$ index. We explicitly write $\mathcal{T}_t^i(w_t^i)$ as a function of $w_t^i$ to emphasize its dependence on the index weights. This demand captures the holdings of both semi- and fully passive investors, it is perfectly inelastic, and shifts with changes in the index.

Let $B^i$ denote the supply for bond $i$, which we assumed fixed for now. By decomposing the demand into an active and passive component, we can write the market-clearing condition for bond $i$ as $B^i = \mathcal{A}_t^i + \mathcal{T}_t^i\left(w_t^i\right)$, where $\mathcal{A}_t^i$ denotes the active demand. For any bond $i$ in fixed supply, an increase in the passive demand implies a decrease in the supply of bonds available to active investors (i.e., a leftward shift in the effective or residual supply). If this increase is exogenous, one can use that variation to analyze whether the demand curves for active investors slope downward. Panel (a) of Figure 1 illustrates this point. If the active demand is inelastic, an exogenous increase in $\mathcal{T}_t^i(w_t^i)$ should lead to a higher bond price.

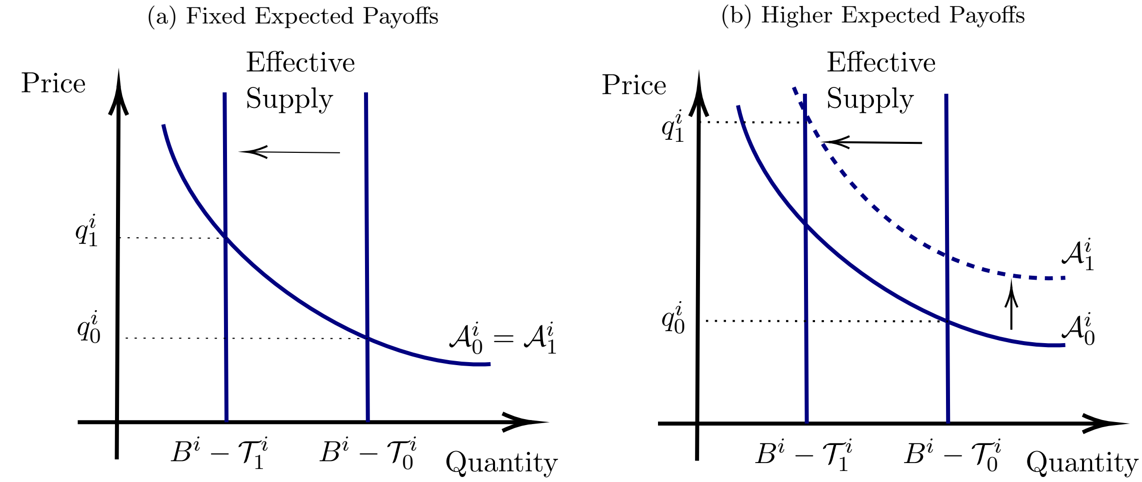
Based on this graphical intuition, one could exploit changes in index weights $w_t^i$ to compute shifts in the passive demand, $\Delta\mathcal{T}_t^i \equiv \mathcal{T}_{t+1}^i(w_{t+1}^i) - \mathcal{T}_t^i(w_t^i)$, and estimate bond price responses around those shifts, $\Delta q_t^i$. Using those responses, we can then back out the following reduced-form (inverse) demand elasticity:

$$\hat{\eta}^i = (-)\frac{\Delta q_t^i}{\Delta\mathcal{T}_t^i}\,\frac{B^i - \mathcal{T}_t^i}{q_t^i}. \tag{1}$$

Exploiting observed variations in index weights $w_t^i$ can still pose challenges. First, changes in $w_t^i$ might be driven by endogenous changes in asset prices or can coincide with large issuances or redemptions. Second, the estimated price reactions in Equation (1) might

[5] For instance, passive and semi-active investors do not want to deviate from the composition of the index they follow to avoid potential tracking error costs.

Figure 1
Index rebalancing and the demand elasticity




Note: The figure depicts a decrease in the effective supply driven by an increase in $\mathcal{T}_t^i$. Panel (a) considers a case in which expected payoffs do not change as a consequence of the lower effective supply. Panel (b) shows a case in which the expected payoffs increase.

capture not only an inelastic demand component but also potential (endogenous) changes in expected payoffs. Put differently, to directly map Equation (1) into a structural elasticity ($\eta^i$), we would need to assume that the intrinsic value of asset $i$ is unaffected by the $\Delta\mathcal{T}_t^i$ shock. However, the shock itself might influence the expected payoffs. For example, for long-term bonds, a larger $\Delta\mathcal{T}_t^i$ may affect next-period payoffs if the shock is persistent. Moreover, the issuer can react to the shock (for instance, by increasing its supply), which may also affect the expected payoffs from holding the asset. If investors anticipate these responses, they should price them.

Panel (b) of Figure 1 illustrates this scenario. If a positive $\Delta\mathcal{T}_t^i$ raises the next-period expected repayment, investors should be willing to pay a higher price for any given quantity of the bond, resulting in an upward shift in the active demand. Failing to account for this effect could lead to the conclusion that the demand curve is steeper (more inelastic) than it actually is. Conversely, if a positive $\Delta\mathcal{T}_t^i$ lowers the expected repayment, the active demand should shift downward, potentially causing the demand curve to appear flatter (more elastic) than it truly is. Since bond prices and payoffs are jointly determined, it is challenging to disentangle the effects on bond prices due to the downward-sloping demand from those resulting from changes in expected payoffs.

Given these challenges we proceed in two steps. In Section 3 we detail a novel identification strategy, based on index rebalancings and their timing, to estimate reduced-form elasticities for risky sovereign bonds. Then, to formally map these price reactions to structural elasticities, we formulate in Section 4 a sovereign default model in which bond prices, the bond supply, and bond payoffs are endogenous and determined simultaneously.

# 3 Empirical Analysis

## 3.1 Identifying Exogenous Shifts in Bond Supply

We exploit end-of-month rebalancings in the J.P. Morgan EMBIGD to identify exogenous shifts in the supply of bonds available to active investors (i.e., the effective supply). The EMBIGD tracks the performance of emerging market sovereign and quasi-sovereign U.S. dollar-denominated bonds issued in international markets.[6] Among bond indexes for emerging economies, the EMBIGD is the most widely used as benchmark and is tracked by funds with combined assets under management (AUM) of around US$300 billion in 2018 (Appendix Figure D2).[7] Unlike other indices that use a traditional market capitalization-based weighting scheme, the EMBIGD limits the weights of countries with above-average debt outstanding (relative to other countries in the index) by including only a fraction of their face amount in the index (referred to as the "diversified face amount"). The goal of this methodology is to achieve greater diversification by lowering the index weight of large countries, and we refer to it as a cap rule.[8]

Rebalancings in the EMBIGD index occur on the last business day of each month in the United States and are triggered by bond inclusions and exclusions. J.P. Morgan announces these updates through a report detailing the updated index composition. Upon the announcement, passive investors mimicking the index composition need to adjust their portfolios by buying or selling bonds to match the new index weights.

Following Pandolfi and Williams (2019), we construct a measure of flows implied by rebalancings (FIR) for each country $c$ on each rebalancing date. The FIR measures the amount of funds that, on a given rebalancing date, enter or leave a country's bonds due to the

[6]The index includes bonds with a maturity of at least 2.5 years and a face amount outstanding of at least US$500 million. To be classified as an emerging economy, a country's gross national income (GNI) per capita must be below an Index Income Ceiling (IIC) for three consecutive years. The IIC is defined by J.P. Morgan and adjusted every year by the growth rate of the World GNI per capita, Atlas method (current US$), provided by the World Bank. Bonds in the index must settle internationally and have accessible and verifiable bid and ask prices. Once included, they can remain in the index until 12 months before maturity. Local law instruments are not eligible.

[7]Appendix Figures D3 and D4 show that U.S. dollar-denominated bonds account for the majority of emerging economies' government debt issued in international markets.

[8]In comparison, the J.P. Morgan Emerging Markets Bond Index Global (EMBIG) has the same bond inclusion criteria as the EMBIGD. The only difference between the EMBIG and the EMBIGD is that while the former uses a market capitalization weighting scheme, the latter adopts the cap rule to limit the weights of countries with above-average debt outstanding. In Appendix Figure D1, we compare the country weights for the EMBIG and EMBIGD.

rebalancing in the portfolio of passive investors tracking the EMBIGD index. It is defined as:

$$\text{FIR}_{c,t} \equiv \frac{\Delta\tilde{\mathcal{T}}_{c,t}}{q_{c,t-1}B_{c,t-1} - w_{c,t-1}\mathcal{W}_{t-1}}. \tag{2}$$

The $\Delta\tilde{\mathcal{T}}_{c,t}$ term captures the change in passive demand implied by the index rebalancing. We normalize $\Delta\tilde{\mathcal{T}}_{c,t}$ by the market value of bonds available to active investors, $q_{c,t-1}B_{c,t-1} - w_{c,t-1}\mathcal{W}_{t-1}$, where $\mathcal{W}$ denotes the AUM passively tracking the EMBIGD. We define the implied change in the passive demand as $\Delta\tilde{\mathcal{T}}_{c,t} \equiv (w_{c,t} - w_{c,t}^{BH})\mathcal{W}_t$. The term $w_{c,t}$ is the benchmark weight for country $c$ at time $t$ and is given by $w_{c,t} \equiv \frac{q_{c,t}B_{c,t}f_{c,t}}{q_t I_t}$, where $q_{c,t}B_{c,t}$ denotes the market value of bonds from country $c$ at time $t$, $q_{c,t}$ denotes the price, and $B_{c,t}$ denotes the face amount (FA). We define the diversified face amount (DFA) as $f_{c,t}B_{c,t}$, where $f_{c,t} \leq 1$ is a diversification coefficient. This coefficient captures the share of country $c$'s face amount outstanding that is included in the index given the EMBIGD cap rule. As we explain in the next subsection, the cap rule implies that $f_{c,t} < 1$ for countries with greater-than-average outstanding debt.[9] The $q_t I_t$ term denotes the market value of the EMBIGD index, where $q_t$ is the unit price of the index and $I_t$ is the number of available index units. Lastly, $w_{c,t}^{BH}$ denotes a "buy-and-hold weight," which we define as $w_{c,t}^{BH} \equiv w_{c,t-1}\frac{q_{c,t}/q_{c,t-1}}{q_t/q_{t-1}} = \frac{q_{c,t}f_{c,t-1}B_{c,t-1}}{q_t I_{t-1}}$. This term can be thought of as the weight of country $c$ in the portfolio of an investor mimicking the EMBIGD absent any bond inclusions or exclusions between $t-1$ and $t$.[10]

As defined, a 1 p.p. FIR implies a 1% reduction in the supply of the country's bonds available to active investors at the time of the rebalancing. The FIR is endogenous and may be correlated with country fundamentals. First, the FIR is affected by countries' sovereign bond issuances. When a country issues new bonds that become part of the index (or redeems existing ones), its weight changes, leading to changes in the FIR. Second, even for countries whose $B_{c,t}$ remains constant, the FIR can be mechanically correlated to present or past bond price changes.

Our empirical strategy addresses these endogeneity issues in two ways. First, for each rebalancing event, we restrict our analysis to countries whose amount outstanding of bonds, $B_{c,t}$, remains unchanged relative to the previous month. In other words, we focus only on countries that do not experience new issuances, bond repurchases, or the removal of bonds

[9] Appendix A describes the rules that the EMBIGD uses to compute the weights of the instruments included in the index. In a purely market capitalization-weighted indexes, $f_{c,t} = 1$ for every country that is part of the index.

[10] In the absence of any inclusions or exclusions, we have $w_{c,t} = w_{c,t}^{BH}$. If the price of a country's sovereign bonds increases more than that of other countries in the index between rebalancing events, the weight of that country will increase. However, investors do not need to rebalance their portfolios since the "buy-and-hold weight" already aligns with the new weight in the index.

from the index due to maturity on the given month.

Second, we exploit the specific features of the cap rule in the EMBIGD's weighting scheme. This rule introduces a weighting coefficient, $f_{c,t}$, that limits countries' weight in the index based on their face amount, and independent of their market value. This characteristic allows us to exclude variations in the FIR that might be correlated with current or past bond price changes. To this end, we construct an instrument for the FIR based on a synthetic index in which country weights are only a function of the diversified face amount, $\tilde{w}_{c,t} \equiv \frac{f_{c,t}B_{c,t}}{\sum_c f_{c,t}B_{c,t}}$. We then compute the relative change in the synthetic index:

$$\frac{\Delta \tilde{w}_{c,t}}{\tilde{w}_{c,t-1}} = \left( \frac{f_{c,t}B_{c,t}}{\sum_c f_{c,t}B_{c,t}} - \frac{f_{c,t-1}B_{c,t-1}}{\sum_c f_{c,t-1}B_{c,t-1}} \right) / \left[ \frac{f_{c,t-1}B_{c,t-1}}{\sum_c f_{c,t-1}B_{c,t-1}} \right]. \tag{3}$$

Given our focus on countries whose debt outstanding in the index remains unchanged ($B_{c,t} = B_{c,t-1}$), our instrument simplifies to:

$$Z_{c,t} \equiv \left( \frac{f_{c,t}}{\sum_c f_{c,t}B_{c,t}} - \frac{f_{c,t-1}}{\sum_c f_{c,t-1}B_{c,t-1}} \right) \ / \left[ \frac{f_{c,t-1}}{\sum_c f_{c,t-1}B_{c,t-1}} \right]. \tag{4}$$

For each country $c$, the $Z_{c,t}$ instrument captures two sources of variation. First, it accounts for fluctuations across rebalancing events due to changes in the diversified face amount $f_{c,t}B_{c,t}$ of other countries included in the index (i.e., changes in $\sum_c Z_{c,t}$). For instance, when a newly issued bond from Brazil is added to the index, the $Z_{c,t}$ values for all other countries decrease proportionally. Additionally, the EMBIGD cap rule allows us to exploit variation across countries within each rebalancing event. As we illustrate in the following subsection, the cap rule introduces heterogeneity in how the $f_{c,t}$ coefficient reacts to additions or deletions of other countries.

## 3.2 The Rebalancings and Cap Rule in Practice

To illustrate how rebalancings and the cap rule operate, we consider an example involving five countries, $c = \{A, B, C, D, E\}$, whose bonds included in the index in month $t-1$. For simplicity, we assume that each of these countries has only one qualifying bond and does not issue or redeem bonds during month $t$. Additionally, we assume that another country, $F$, issues an eligible bond during month $t$, which will be included in the index on the rebalancing date at the end of that month.

Panel a of Table 1 presents the assumed face amount $FA_c$ for each country in the index, before and after the rebalancing date $t$. The columns labeled $DFA_c$ display the diversified face amounts (i.e., $f_cB_c$) calculated based on the EMBIGD methodology. Each month, J.P. Morgan computes the "Index Country Average" ($ICA_t$), which is the average country-level

Table 1
The cap rule
Panel a. Face amount vs diversified face amount

| Country | Before Rebalancing | | After Rebalancing | |
|---|---|---|---|---|
| | $FA_{c,t-1}$ | $DFA_{c,t-1}$ | $FA_{c,t}$ | $DFA_{c,t}$ |
| A | 1,000 | 1,000 | 1,000 | 1,000 |
| B | 2,000 | 2,000 | 2,000 | 2,000 |
| C | 3,000 | 3,000 | 3,000 | 3,000 |
| D | 7,000 | 6,429 | 7,000 | 6,769 |
| E | 12,000 | 10,000 | 12,000 | 11,000 |
| F | - | - | 8,000 | 7,615 |
| $ICA$ | 5,000 | | 5,500 | |
| $FA_{max}$ | 12,000 | | 12,000 | |

Panel b. Heterogeneity induced by the cap rule

| $c$ | $\tilde{w}_{c,t-1} = \frac{DFA_{c,t-1}}{\sum_c DFA_{c,t-1}}$ | $\tilde{w}_{c,t} = \frac{DFA_{c,t}}{\sum_c DFA_{c,t}}$ | $Z_t = \frac{\tilde{w}_{c,t} - \tilde{w}_{c,t-1}}{\tilde{w}_{c,t-1}}$ |
|---|---|---|---|
| A | 4.46% | 3.19% | -28.54% |
| B | 8.92% | 6.37% | -28.54% |
| C | 13.38% | 9.56% | -28.54% |
| D | 28.66% | 21.57% | -24.75% |
| E | 44.59% | 35.05% | -21.39% |
| F | - | 24.26% | - |

Note: The table illustrates the role of the cap rule. Panel (a) presents the assumed face amounts for each country and computes the diversified face amount using Equation (5). Panel (b) displays the synthetic index weights derived from the diversified face amount, with the final column showing the percentage change in these weights, i.e., $Z$.

face amount of bonds included in the index. Using this average, the diversified face amount for each country is then computed as follows:

$$DFA_{c,t} = \begin{cases} ICA_t \times 2 & \text{if } FA_{c,t} = FA_{max,t} \\ ICA_t + \frac{ICA_t}{FA_{max_t} - ICA_t} (FA_{c,t} - ICA_t) & \text{if } FA_{c,t} > ICA_t \\ FA_{c,t} & \text{if } FA_{c,t} \leq ICA_t, \end{cases} \tag{5}$$

where $FA_{max}$ refers to the country with the largest face amount (see Appendix A for additional details). In our example, countries $D$ and $E$ are capped in periods $t-1$ and $t$ (since their face values exceed the $ICA$), while country $F$ becomes capped in $t$.

Panel b of Table 1 reports the synthetic weights $\tilde{w}_{c,t}$, which are only a function of the diversified face amount, and our $Z$ instrument, computed based on Equation (4). Since we only consider countries with a constant face amount outstanding, changes in $\tilde{w}$, and therefore our instrument $Z$, are exclusively driven by country $F$'s issuance and are uncorrelated with price changes.

From this simple example, one can easily identify the sources of variation that we exploit. First, the issuance of a new bond by country $F$ and its inclusion in the index reduce the weights of all other countries. In the absence of the cap rule, a purely market capitalization-based index would rely solely on this mechanism, leading to a relative decrease in index weights that is homogeneous across all other countries. However, the cap rule introduces heterogeneity in the relative changes in the synthetic weights. This variation arises because the diversified face amount (which is used to calculate $\tilde{w}$) is capped for countries with above-average amounts of outstanding bonds, and this cap changes after the inclusion of country $F$.[11] By relaxing the cap for countries with above-average face amounts ($D$ and $E$), the addition of country $F$ to the index results in a smaller decrease in the weights of countries with greater outstanding face amounts. An analogous mechanism would ocurr if the new addition in month $t$ leads to a decrease in the $ICA$.

### 3.3 Estimation Strategy

We exploit the rebalancing-driven shifts in the available supply, along with the timing of the EMBIGD and the cap rule, to estimate a demand elasticity for sovereign bonds. We focus on 5-day symmetric windows around each rebalancing date, where we estimate the average price reactions to exogenous changes in the FIR using our $Z_{c,t}$ instrument.[12]

We adopt an instrumented difference-in-differences design and estimate the following specification using two-stage least squares (2SLS):

$$\log(q_{i,t,h}) = \theta_{c(i),t} + \theta_{b(i),t} + \gamma \mathbb{1}_{h\in Post} + \beta(FIR_{c(i),t} \times \mathbb{1}_{h\in Post}) + \mathbf{X}_{i,t} + \varepsilon_{i,t,h}, \quad (6)$$

where $FIR_{c(i),t}$ are the flows implied by the rebalancing to country $c$ in rebalancing day $t$, instrumented by $Z_{c,t}$ in a first stage regression. The term $q_{i,t,h}$ is the price of bond $i$ at rebalancing event $t$, $h$ trading days before or after the rebalancing information is released. For example, $h = 1$ indicates the first trading day after J.P. Morgan releases the EMBIGD's new composition. This release occurs during trading hours on the last business day of each month, so $h = 1$ corresponds to that same day. The indicator $\mathbb{1}_{h\in Post}$ equals 1 in the $h$ days after the rebalancing and 0 in the $h$ days before, $\theta_{c(i),t}$ are country-month fixed effects, and $\theta_{b(i),t}$ are bond characteristics-month fixed effects, including maturity, rating, and bond

[11] The inclusion of the bond from country $F$ increases the average country face amount outstanding ($ICA$) from \$5,000 to \$5,500. The diversified face amounts of countries $A$, $B$, and $C$ are unaffected because their face amounts are below the $ICA$. However, the increase in the $ICA$ relaxes the cap for initially capped countries $D$ and $E$, altering their diversified face amounts outstanding even though their face values remain constant.

[12] Appendix Figure D5 presents a visual representation of each rebalancing event and the specific days included in the estimation window.

type (sovereign or quasi-sovereign). Lastly, $\mathbf{X}_{i,t}$ is a vector of monthly bond controls, which includes the bond's face amount and (beginning-of-month) spread. Our coefficient of interest is $\beta$, which captures the effect of shifts in the available supply of a country's index bonds on their prices. Specifically, it measures how a 1 p.p. increase in the FIR influences the average change in the log price of bonds around the rebalancing date.

Our preferred specification replaces the country-month fixed effects, bond characteristics-month fixed effects, and bond controls with bond-month fixed effects, $\theta_{i,t}$. This specification allows us to exploit variation both within and across rebalancing events. Additionally, leveraging the cap rule, we present results that focus exclusively on cross-country variation within an event. To this end, we include in our specification month-$\mathbb{1}_{h\in Post}$ fixed effects.

We also estimate a leads-and-lags regression in which the instrumented FIR is interacted with trading-day dummies around each rebalancing event. This analysis allows us to explore the dynamic effect of the FIR and test for parallel trends before the rebalancing. We estimate the following regression via 2SLS:

$$\log(q_{i,t,h}) = \theta_{c(i),t} + \theta_{b(i),t} + \sum_{h\notin -2} \gamma_h \mathbb{1}_h + \sum_{h\notin -2} \beta_h (FIR_{c(i),t} \times \mathbb{1}_h) + \mathbf{X}_{i,t} + \varepsilon_{i,t,h}, \qquad (7)$$

where $\mathbb{1}_h$ are dummy variables equal to 1 for the $h$ trading day in our $[-5, 5]$ estimation window and 0 otherwise.

### 3.4 Data and Summary Statistics

We collect data from various sources to construct our FIR measure. The majority of the variables used in the analysis are sourced directly from J.P. Morgan. Our sample period spans from 2016 to 2018. One variable in particular is challenging to measure: the AUM of funds that passively track the EMBIGD, $\mathcal{W}_t$. While J.P. Morgan provides data on the amount of assets benchmarked against their indexes, it does not distinguish between passive and active funds. Even if such data were available, many active funds may passively manage a significant share of their portfolios, as highlighted by Pavlova and Sikorskaya (2022).

To compute $\mathcal{W}_t$, we start with J.P. Morgan data on assets tracking the EMBIGD, which we then adjust based on an estimate of the share of passive funds. The estimation process involves the following steps. We retrieve data from Morningstar on the asset holdings of funds benchmarked against the EMBIGD and EMBI Global Core for 2016–2017.[13,14] For

[13]The EMBI Global Core uses the same diversification methodology as the EMBIGD to calculate the bond weights, as described in Appendix A. The criteria for including bonds in the EMBI Global Core is the same as that for the EMBIGD (and the EMBI Global), except the minimum face amount of the bonds must be US$1 billion and the maturity required to be maintained in the index is of at least one year.

[14]The sample periods utilized in the paper are determined by data access constraints.

Table 2
Summary statistics

| Variable | Mean | Std. Dev. | 25th Pctl | 75th Pctl | Min | Max |
|---|---|---|---|---|---|---|
| log(Price) | 4.64 | 0.13 | 4.59 | 4.68 | 3.07 | 5.19 |
| Instrumented FIR (%) | -0.15 | 0.20 | -0.32 | 0.00 | -0.66 | 0.23 |
| Stripped spread (bps) | 278 | 288 | 128 | 356 | 0 | 4904 |
| EIR duration (%) | 6.36 | 3.92 | 3.48 | 7.71 | -0.03 | 19.08 |
| Average life (years) | 9.6 | 8.9 | 4.0 | 9.9 | 1.0 | 99.8 |
| Face amount (billion U.S. dollars) | 1.3 | 0.8 | 0.7 | 1.6 | 0.5 | 7.0 |

Note: This table displays summary statistics for the main variables in the analysis. *Stripped Spread* is the difference between a bond yield-to-maturity and the corresponding point on the U.S. Treasury spot curve, where the value of collateralized flows are "stripped" from the bond. *EIR Duration* measures the sensitivity of dirty prices to parallel shifts of the U.S. interest rates, expressed as the percentage change of dirty price if all U.S. interest rates change by 100 basis points. *Average Life* is the weighted average period until principal repayment. Sources: Bloomberg, Datastream, J.P. Morgan Markets, Morningstar Direct, and authors' calculations.

each fund, we compute their $Passive\ Share = 100 - Active\ Share$, where $Active\ Share$ is the measure developed by Cremers and Petajisto (2009).[15] We estimate this variable at the country level, which is the level at which we compute the FIR.[16] This allows us to separate, even for active funds, the fraction of a fund's portfolio that behaves passively. We then compute the average $Passive\ Share$ weighted by each fund's AUM. With this strategy, we obtain an estimated passive fund share of 50%.[17] We then compute our $\mathcal{W}_t$ measure by adjusting the AUM benchmarked against the EMBIGD using a rescaling factor of 50%.[18]

We gather data on individual bond prices from Datastream and obtain several bond characteristics (maturity and duration, among others) directly from J.P. Morgan Markets. To clean our dataset, we drop extreme values of daily returns, stripped spreads, and $Z_{c,t}$.[19] We drop stripped spreads below 0 or above $5,000$ basis points as well as observations below the 5th or above the 95th percentiles in terms of the distribution of $Z_{c,t}$. The reason for the latter is that extreme values of $Z_{c,t}$ could be driven by large, pre-announced changes in the EMBIGD and thus are not appropriate for our identification strategy, which relies on the assumption that most information is known on the last business day of the month. Finally, we exclude bond-month observations that experience daily returns below the 1st and above the 99th percentiles.

[15]The active share measure evaluates the degree of active management within funds. It quantifies how much the holdings of a fund differ from the benchmark index it is compared against.

[16]We calculate the *Active Share* at the country level by using the country weights in the index and in the funds' portfolios rather than bond weights. For the portfolios, we only assign bonds to a given country if they are included in the EMBIGD. Specifically, a country's weight in a portfolio is determined by adding together the weights of all bonds from that country that are included in the EMBIGD.

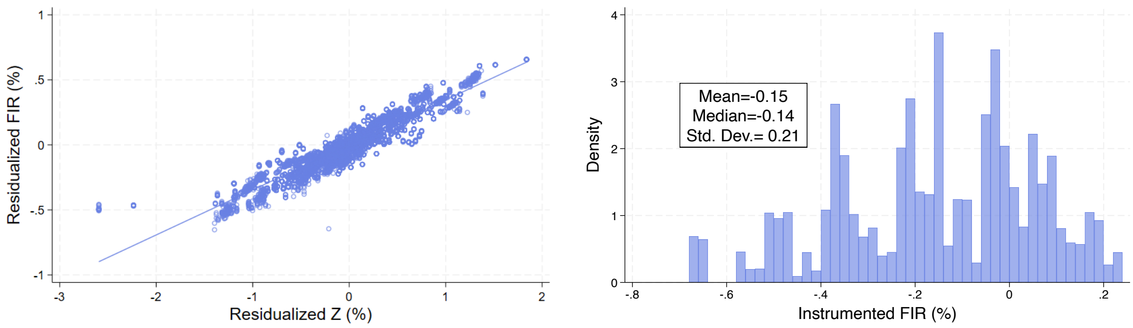
[17]Appendix Table D1 provides results using alternative shares of passive funds used to construct the FIR measure. Although our quantitative estimates change slightly, the qualitative implications remain the same.

[18]For comparison, we also construct the *Active Share* at the bond level, and obtain a value-weighted average of 72%. Cremers and Petajisto (2009) show an average value-weighted *Active Share* that fluctuates between 55% and 80%.

[19]Stripped spread is defined in the notes of Table 2.

Figure 2
Flows implied by rebalancing (FIR)

(a) Relation between FIR and $Z$ (b) Distribution of instrumented FIR values




Notes: Panel (a) presents a scatter plot of the FIR and the $Z$ instrument. Both variables are residualized based on a regression with rebalancing-month and country fixed effects. The FIR is computed as described in Equation (2) and $Z$ is computed according to Equation (4). Panel (b) shows a histogram of the instrumented FIR. The sample period is 2016–2018.

Our final dataset comprises 131,820 bond-time observations for 751 bonds across 68 countries. Table 2 displays summary statistics for our main variables. The bonds in our sample have an average stripped spread of 278 basis points, an average maturity of 10 years, and an average face amount of US$1.3 billion.

Panel (a) of Figure 2 presents the results of our first stage. It shows a scatter plot of the FIR and the $Z_{c,t}$ instrument after both variables have been residualized with rebalancing-month and country fixed effects. There is a clear positive relationship between the variables, with an R-squared value of 86%. Panel (b) shows the distribution of our instrumented FIR measure. The values range from $-0.7\%$ to 0.25%, featuring more negative than positive observations. This is consistent with the fact that the number of bonds included in the EMBIGD has increased over time. Given that we restrict our analysis to countries with a constant face amount, the inclusion of bonds from other countries typically reduces the weight of the sample countries.[20]

## 3.5 Results

Table 3 reports the results of our baseline estimation using a five-day window around each rebalancing event (i.e., $h \in [-5, 5]$).[21] Our coefficient of interest, $\beta$, is always positive and statistically significant in the different specifications. The estimate in our preferred specification, with bond-rebalancing and bond-month fixed effects (column 4), implies that a

[20]When a bond is added to the index, it generally reduces the weight of other bonds based on their total face amount. However, in certain situations, it can increase the weight of certain countries by relaxing face amount caps.

[21]In Appendix Table D2 we present also the estimates obtained with simple OLS regressions of log bond prices on the FIR. In this case, the coefficients are slightly lower than in the 2SLS, consistent with a potential downward bias due to the endogeneity of the FIR measure to price changes around the rebalancing date.

1 p.p. increase in the FIR increases bond returns by around 0.30 p.p.[22]

Table 3
Log price and FIR

| Dependent Variable: Log Price | | | | | | |
|---|---|---|---|---|---|---|
| | Symmetric window: [-5:+5] | | | | Excl. h=-1 | |
| FIR | 0.006 | | | | | |
| | (0.808) | | | | | |
| FIR X Post | 0.231 | 0.232 | 0.231 | 0.300 | 0.263 | 0.319 |
| | (0.099) | (0.100) | (0.099) | (0.134) | (0.098) | (0.135) |
| Post | 0.001 | 0.001 | 0.001 | | 0.001 | |
| | (0.000) | (0.000) | (0.000) | | (0.000) | |
| Bond FE | Yes | Yes | No | No | No | No |
| Month FE | Yes | No | No | No | No | No |
| Bond Characteristics-Month FE | No | Yes | No | No | No | No |
| Country-Month FE | No | Yes | No | No | No | No |
| Bond-Month FE | No | No | Yes | Yes | Yes | Yes |
| Month-Post FE | No | No | No | Yes | No | Yes |
| Bond Controls | No | Yes | No | No | No | No |
| Observations | 105,548 | 105,508 | 105,548 | 105,548 | 84,433 | 84,433 |
| N. of Bonds | 738 | 738 | 738 | 738 | 738 | 738 |
| N. of Countries | 68 | 68 | 68 | 68 | 68 | 68 |
| N. of Clusters | 1,576 | 1,575 | 1,576 | 1,576 | 1,576 | 1,576 |
| F (FS) | 654 | 1,616 | 1,666 | 476 | 1,670 | 476 |

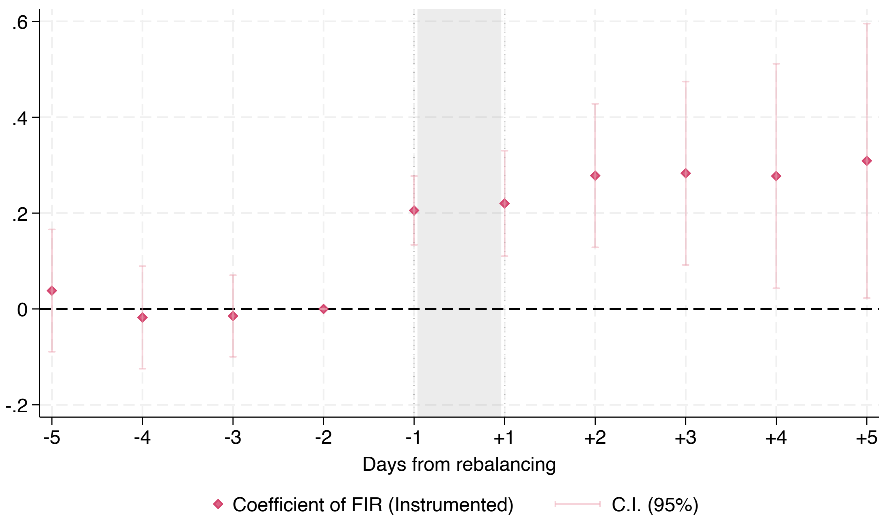
Note: This table presents 2SLS estimates of log bond prices on the FIR measure (Equation (2)), instrumented by $Z$ (Equation (4)), around rebalancing dates. The first- and second-stage equations are described in Equation (6). The estimations use a symmetric five-trading-day window, with *Post* as an indicator variable (equal to 1 for the five trading days after rebalancing, and 0 otherwise) in Columns 1-4. Month fixed effects are dummy variables equal to 1 for each rebalancing month (0 otherwise), and bond characteristics are fixed effects that interact maturity, ratings, and bond type fixed effects. Maturity fixed effects are constructed by dividing a bond's time to maturity into four different categories: short (less than 5 years), medium (5–10 years), long (10–20 years), and very long (20+ years). Ratings from each bond are from Moody's. Bond type differentiates sovereign from quasi-sovereign bonds. Bond controls indicate whether the estimation includes the log face amount and log stripped spread of the bond. The last two columns in the analysis drops the trading day before rebalancing and the trading day $h = +5$ to have a four-trading-day symmetrical window around the rebalancing. Standard errors are clustered at the country-month level, and the sample period is 2016–2018.

One potential concern with these results is that bonds receiving a larger or smaller FIR during the rebalancings are on different price trends even before the rebalancing date. To

[22]In Appendix Table D3 we estimate an OLS regression with an alternative FIR that holds prices constant, using previous rebalancing period prices. Results are similar to our main estimates. Additionally, our results are robust to alternative windows around the rebalancing events (Appendix Table D4) and to excluding quasi-sovereign bonds from the analysis (Appendix Table D5).

show that this is not the case, we use the specification with leads and lags described in Equation (7). The estimated $\beta_h$ coefficients are reported in Figure 3.

Figure 3
Leads and lags coefficients




Note: This figure presents leads and lags coefficients from a 2SLS estimation of bond log prices on a set of trading-day dummies around each rebalancing event, using the same 2SLS procedure as in Table 3. The estimation includes bond characteristics-month fixed effects (maturity, rating, and bond type). The shaded area indicates the rebalancing on the month's last business day, with $h = +1$ for returns on that day and $h = -1$ for returns on the preceding business day. The vertical red lines show a 95% confidence interval for each horizon. Standard errors are clustered at the country-month level.

On the initial four of the five trading days before the index rebalancing, changes in the FIR are not associated with systematic differences in bond prices. Instead, in the trading days after the event, the coefficient increases, becomes positive and significant, and eventually stabilizes below 0.35 by the end of our estimation window. We do observe a slight anticipation in the day before the index rebalancing, which is not uncommon in these setups. For example, this is consistent with the patterns of portfolio rebalancings by different institutional investors highlighted in Escobar et al. (2021), who show that institutional investors could move in the day before the actual index rebalancing event. In the last two columns of Table 3, we show the estimates based on our preferred specification of Equation (6) but after excluding the trading day before the index rebalancing. This leads to estimates between 0.26 and 0.32, which we take as our baseline since it does not contain any anticipation effect in the pre-period.

A related concern is the potential for additional anticipation throughout the month. Between the middle and end of every month, J.P. Morgan releases preliminary estimates about end-of-month face amounts, market values, and bond weights. While it is conceivable

Table 4
Log price and FIR: Role of default risk

| Dependent Variable: Log Price | | | | |
|---|---|---|---|---|
| | High Spread | | Low Spread | |
| FIR X Post | 0.406 | 0.406 | 0.116 | 0.115 |
| | (0.147) | (0.146) | (0.097) | (0.097) |
| Bond FE | Yes | No | Yes | No |
| Month FE | Yes | No | Yes | No |
| Bond-Month FE | No | Yes | No | Yes |
| Observations | 42,169 | 42,166 | 42,267 | 42,267 |
| N. of Bonds | 500 | 500 | 494 | 494 |
| N. of Countries | 62 | 62 | 51 | 51 |
| N. of Clusters | 1,217 | 1,217 | 869 | 869 |
| F (FS) | 544 | 1,889 | 421 | 820 |

Note: This table presents 2SLS estimates of bond log prices on the FIR measure, instrumented by $Z$, across rebalancing dates. The sample is divided into high-spread bonds in Columns 1 and 2, above the median stripped spread, and low-spread bonds in Columns 3 and 4, below the median. The sample period and the 2SLS procedure are identical to those described in Table 3. The estimation excludes the trading day before rebalancing and the trading day $h = +5$ to have a four-trading-day symmetrical window around the rebalancing. The coefficients for *Post* and FIR are included in the estimation but not reported for brevity. Standard errors are clustered at the country-month level.

that active investors traded on this information before the actual index rebalancing date, our data do not support this behavior. Normally, if a significant number of investors were anticipating the index rebalancing, we would expect to observe pre-trends in bond prices before the actual event. However, our analysis reveals no correlation between the FIR and bond returns in the week leading up to the rebalancing (with the only exception being the day before the event). Lastly, if part of the rebalancing-driven inflows were to occur before the event, our FIR measure would overestimate them at the index rebalancing date. This, in turn, implies that our estimates can be understood as a lower bound.[23]

The documented effects are heterogeneous across bonds with varying levels of default risk. To show this heterogeneity, we divide our sample into high- and low-spread bonds, those above and below the median spread in our sample, respectively. We estimate Equation (6) for each of these subsamples and report the results in Table 4. The table shows that the price of high-spread bonds is more sensitive to rebalancing shocks, with a 1 p.p. increase

[23] Appendix Table D1 shows how our estimates change as we proportionally decrease the FIR measure (due to a lower share of passive funds). These results could serve as guidance for what might happen if the FIR measure were lower due to some investors' portfolio rebalancings being anticipated.

in the FIR associated with a 0.41 p.p. increase in bond returns. In contrast, for low-spread bonds, the effect is smaller (around 0.11 p.p.) and not statistically significant.[24] Overall, these findings suggest that investors demand a premium as compensation for holding risky bonds, that is, an inconvenience yield.

We can directly map the estimated bond price reactions to a reduced-form demand elasticity. Based on our FIR measure, we can rewrite Equation (1) as $\hat{\eta} = (-)\frac{\Delta \log(q_t^i)}{FIR_{c,t}}$, which is precisely what the $\beta$ coefficient in Equation (6) captures. Based on the estimates in Table 3 (last columns), the inverse demand elasticity is around $-0.3$, implying a demand elasticity of $-3$. Our inverse demand elasticity estimate is higher (in magnitude) than those for sovereign bonds issued in advanced economies, but smaller relative to other asset classes, such as equities. In Appendix Figure D6, we compare our estimates with other studies.

# 4 A Sovereign Debt Model with Inelastic Investors

We next formulate a quantitative sovereign debt model to study the impact of a downward-sloping demand on a government's supply of risky bonds. The model features a risk-averse government that lacks commitment and issues long-term debt in international debt markets. We introduce a rich demand structure, allowing us to capture a downward-sloping demand for government bonds that we discipline based on our empirical estimates.

## 4.1 Model Setup

We consider a small open economy with incomplete markets. Output $y$ is exogenous and follows a continuous Markov process with a transition function $f_y(y_{t+1} \mid y_t)$. Preferences of the representative consumer are given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \tag{8}$$

where $\beta$ is the discount factor, $c$ denotes consumption, and the function $u(.)$ is strictly increasing and concave.

An infinite-lived, risk-averse government issues long-term bonds in international markets. Let $B_{t-1}$ denote the beginning-of-period stock of government debt. The government lacks commitment and can default on its debt. Each unit of $B$ matures in the next period with probability $\lambda$. If a bond does not mature (and the government does not default), it pays a

[24] Appendix Table D6 divides bonds into three groups according to their spreads. We find that bond prices are positively associated with the FIR for both high (above 302 basis points) and medium (between 158 and 302 basis points) spread bonds. Instead, for low spread bonds (below 158 basis points), the relationship is statistically insignificant. Additionally, the estimated coefficient increases with the risk profile of the bonds.

coupon $\nu$. Let $d_t = \{0, 1\}$ denote the default policy, where $d = 1$ indicates a default. Default leads to a temporary exclusion from international debt markets and an exogenous output loss, $\phi(y_t)$. The government is benevolent and chooses $\{d_t, B_t\}$ to maximize Equation (8), subject to the economy's resource constraint.

International markets are competitive, and investors discount payoffs at the risk-free rate. These markets are populated by a large number of heterogeneous investors ($J$) who differ in how they allocate their funds across bonds. We introduce a downward-sloping demand by assuming that each investor $j$ has a mandate or rule that specifies how they should allocate their funds across the $N$ bonds (each issued by a different country). A fraction of these investors are passive and track the composition of a benchmark bond index $\mathcal{I}$, of which the government's bonds are part of it.

### 4.2 Inelastic Investors

Let $j = \{1, ..., J\}$ denote the investor. Let $i = \{1, ..., N\}$ denote the set of bonds in which investors can invest and let $\boldsymbol{w}_t = \left\{w_t^1, ..., w_t^N\right\}$ denote the vector of time-varying index weights for each constituent bond of index $\mathcal{I}$. We define $x_{jt}^i = \frac{q_t^i B_{jt}^i}{W_{jt}}$ as the share of wealth that investor $j$ invests in bond $i$ at time $t$. The term $q_t^i$ denotes the unit price of bond $i$, $B_{j,t}^i$ denotes the holdings of investor $j$ in bond $i$, and $W_{j,t}$ denotes their wealth. Following Gabaix and Koijen (2021), the share $x_{jt}^i$ is given by the following exogenous mandate:

$$x_{jt}^i = \theta_j \left(\xi_j^i e^{\Lambda_j \hat{\pi}_{i,t}\left(r_{t+1}^i\right)}\right) + (1 - \theta_j)\, w_t^i, \tag{9}$$

where $\theta_j$ parameterizes the degree of activeness of investor $j$. Purely passive investors can be characterized by $\theta_j = 0$, indicating that their portfolio simply replicates the benchmark index $\mathcal{I}$. Conversely, active and semi-active investors are those with $\theta_j \in (0, 1]$. Within their active allocation, investors apportion a fixed fraction $\xi_j^i$ of their wealth to bond $i$ and a varying component determined by $\Lambda_j \hat{\pi}_{i,t}\left(r_{t+1}^i\right)$, where $\Lambda_j > 0$ parameterizes their demand elasticity and $\hat{\pi}_{i,t}(.)$ is an arbitrary function of the next-period excess return of bond $i$, $r_{t+1}^i$. For instance, if $\hat{\pi}_{i,t}\left(r_{t+1}^i\right) = \mathbb{E}_t\left(r_{t+1}^i\right)$, investors allocate a higher share of their wealth to bonds with higher expected excess returns.

The reduced-form mandate in Equation (9) allows us to introduce an aggregate demand elasticity for bond $i$ that can be parameterized by $\boldsymbol{\Lambda} \equiv \{\Lambda_1, .., \Lambda_J\}$. While this mandate can have different microfoundations (as shown in Appendix B), we take it as given for our analysis. Our goal is not to explain the reasons behind the inelastic demand for risky bonds but rather to examine its implications. After aggregating all the individual demands, the market-clearing condition can be expressed as:

$$q_t^i B_t^i = \tilde{\mathcal{A}}_t^i + \tilde{\mathcal{T}}_t^i(w_t^i), \tag{10}$$

where $B_t^i$ is the end-of-period bond supply, and $\tilde{\mathcal{A}}_t^i \equiv \sum_j W_{j,t}\theta_j \left(\xi_j^i e^{\Lambda_j \hat{\pi}_{i,t}}\right)$ and $\tilde{\mathcal{T}}_t^i(w_t^i) \equiv \sum_j W_{j,t}\left(1-\theta_j\right) w_t^i$ denote the market-value active and passive demands, respectively. The passive demand, $\tilde{\mathcal{T}}_t^i(w_t^i)$, reflects the portion of investors' holdings aimed at replicating the index composition. It captures the holdings of both semi- and fully- passive investors. We write $\tilde{\mathcal{T}}_t^i(w_t^i)$ as a function of $w_t^i$ to emphasize its dependence on the index weights.

We now put more structure behind the investor demand, allowing us to derive a closed-form solution for the price. We assume that $\hat{\pi}_{i,t}(r_{t+1}^i) = \frac{\mathbb{E}_t\left(r_{t+1}^i\right)}{\mathbb{V}_t\left(r_{t+1}^i\right)}$ so that the active demand is a function of the bond's expected excess return and its variance (the Sharpe ratio).[25] We define $\mathcal{R}_{t+1}^i$ as the next-period repayment per unit of the bond so that $r_{t+1}^i \equiv \frac{\mathcal{R}_{t+1}^i}{q_t^i} - r_f$, where $r_f$ denotes the risk-free rate. Based on these definitions and the market-clearing condition in Equation (10), the equilibrium bond price is given by

$$q_t^i = \frac{\mathbb{E}_t\left(\mathcal{R}_{t+1}^i\right)}{r^f}\,\Psi_t^i. \tag{11}$$

The term $\frac{\mathbb{E}_t\left(\mathcal{R}_{t+1}^i\right)}{r^f}$ captures the price under perfectly elastic investors, which is only a function of the expected next-period repayment. On the other hand, $\Psi_t^i$ captures the downward-sloping component of demand, which is given by

$$\Psi_t^i \equiv 1 - \kappa_t^i\left(\mathbf{\Lambda}\right)\frac{\mathbb{V}_t\left(\mathcal{R}_{t+1}^i\right)}{\mathbb{E}_t\left(\mathcal{R}_{t+1}^i\right)}\left(B_t^i - \mathcal{T}_t^i - \bar{\mathcal{A}}_t^i\right). \tag{12}$$

The term $\kappa_t^i\left(\mathbf{\Lambda}\right) \equiv \frac{1}{\sum_j \Lambda_j W_{j,t}\theta_j \xi_j^i}$ characterizes the elasticity of the active demand for bond $i$. The $B_t^i - \mathcal{T}_t^i$ component is the effective or residual supply, while $\bar{\mathcal{A}}_t^i$ captures the inelastic portion of the active demand, which is determined by the fixed component of investors' mandates, $\xi_j^i$ (see Appendix B for the details and derivations). Notice that when $\kappa_t^i\left(\mathbf{\Lambda}\right) = 0$, the active demand is perfectly elastic and the bond's price only depends on its expected repayment. When $\kappa_t^i\left(\mathbf{\Lambda}\right) > 0$, the demand is inelastic and differs across bonds with different repayment variances (i.e., default risk), which is consistent with our empirical findings. We view the $\Psi_t^i$ term as capturing an inconvenience yield, that is, a premium demanded by investors as compensation for holding the bond, in excess of its default risk.

[25] This is a similar specification to the one in Gabaix and Koijen (2021), which is a function of expected excess returns and a shock to tastes or perceptions of risk.

### 4.3 Government Problem: Recursive Formulation

We focus on a Recursive Markov Equilibrium (RME) and represent the infinite horizon decision problem of the government as a recursive dynamic programming problem (see Appendix C.2 for the equilibrium definition).

We introduce the pricing equations derived in the previous subsection into the problem of the sovereign government, who issues a risky bond that is part of the index $\mathcal{I}$. For simplicity, we will omit the $i$ subindex in what follows. In order to have a recursive formulation of the problem, we assume that the passive demand is given by $\mathcal{T}' = \mathcal{T}(\tau, B')$ where $B'$ denotes the end-of-period stock of government bonds and $\tau$ is a (time-varying) index weight. We assume that $\tau$ is exogenous and follows a continuous Markov process with a transition function $f_\tau(\tau' \mid \tau)$. Given an end-of-period bond supply $B'$, the market-clearing condition can we written as $B' = \mathcal{A}'(.) + \mathcal{T}(\tau, B')$, where $\mathcal{A}'(.)$ denotes the (end-of-period) active demand.

Under these assumptions, the state space can be summarized by the $n$-tuple $(h, B, s)$, where $h$ captures the government's current default status, $B$ is the beginning-of-period stock of debt, and $s = (y, \tau)$ are the exogenous states. For a given default status $h$ and choice of $B'$, the resource constraint of the economy can be written as

$$\begin{aligned} c(h=0, B, y, \tau; B') &= y + q\left(y, \tau, B'\right)\left(B' - (1-\lambda)B\right) - \left(\lambda + (1-\lambda)\nu\right)B, \\ c(h=1, y) &= y - \phi_j(y), \end{aligned} \tag{13}$$

where $q(y, \tau, B')$ denotes the price of a unit of debt, $B' - (1-\lambda)B$ are new bond issuances, and $(\lambda + (1-\lambda)\nu)B$ are current debt services.

If the government is not in default, its value function is given by

$$V(y, \tau, B) = \text{Max}_{d=\{0,1\}} \left\{ V^r(y, \tau, B), V^d(y) \right\}, \tag{14}$$

where $V^r(.)$ denotes the value function in case of repayment and $V^d(.)$ denotes the default value. If the government chooses to repay, its value function is given by the following Bellman equation:

$$\begin{aligned} V^r(y, \tau, B) &= \text{Max}_{B'} \;\; u(c) + \beta\, \mathbb{E}_{s'|s} V\left(y', \tau', B'\right), \\ &\text{subject to} \quad c = y + q(y, \tau, B')\left(B' - (1-\lambda)B\right) - \left(\lambda + (1-\lambda)\nu\right)B. \end{aligned} \tag{15}$$

While in default, the country is excluded from debt markets and cannot issue new debt. The government exits a default with probability $\theta$, with no recovery value. Additionally, we assume that demand from passive investors is zero during the default period. Under these assumptions, the value function in case of default is given by

$$V^d(y) = u(y - \phi(y)) + \beta\,\mathbb{E}_{s'|s}\left[\theta V\left(y', \tau', 0\right) + (1-\theta)\,V^d\left(y'\right)\right]. \tag{16}$$

Based on the analysis in Section 4.2, given an exogenous state $\{y, \tau\}$ we can write the bond price function that the government faces as a function of $B'$ as follows:

$$q\left(y, \tau, B'\right) = \beta^\star\,\mathbb{E}_{s'|s}\left[\mathcal{R}\left(y', \tau', B'\right)\right]\ \Psi\left(y, \tau, B'\right), \tag{17}$$

where $\beta^\star \equiv 1/r_f$ is the lenders' discount factor, $\mathcal{R}'(.) \equiv \mathcal{R}\left(y', \tau', B'\right)$ denotes the next-period repayment function, and $\Psi(y, \tau, B')$ captures the downward-sloping component of the active demand. The next-period repayment function is given by

$$\mathcal{R}\left(y', \tau', B'\right) = \left[1 - d\left(y', \tau', B'\right)\right]\left[\lambda + (1-\lambda)\left(\nu + q(y', \tau', B'')\right)\right], \tag{18}$$

where $d(y', \tau', B')$ is the next-period default choice and $q(y', \tau', B'')$ denotes the next-period bond price, which is a function of next-period exogenous states, $\{y', \tau'\}$, and the next-period debt, $B'' \equiv B'\left(y', \tau', B'\right)$.

From Equations (17) and (18), it is clear that the bond price decreases with the expected default probability. Specifically, a larger $B'$ (weakly) increases the default risk (conditional on a level of output), and thus $q(y, \tau, B')$ (weakly) decreases in $B'$. The $\Psi\left(y, \tau, B'\right)$ term introduces another mechanism for the bond price to be decreasing in $B'$: the downward-sloping demand of active investors.

When choosing its optimal debt policy, the government internalizes the effects of changes in $B'$ on the bond price $q(y, \tau, B')$, accounting for both the impact on expected repayment and the downward-sloping demand component. Let $\varepsilon \equiv \frac{\partial \log q(.)}{\partial \log B'}$ denote the (inverse) supply elasticity, which can be expressed as

$$\epsilon = \frac{\partial \log \mathbb{E}_{s'|s}\mathcal{R}'(.)}{\partial \log B'} + \frac{\partial \log \Psi(.)}{\partial \log B'}. \tag{19}$$

The first term on the right-hand side captures the elasticity of the expected repayment function with respect to the bond supply. This elasticity is (weakly) negative because a larger $B'$ increases default risk and reduces the expected bond payoff. The second term captures the additional decline in the bond price resulting from the downward-sloping demand. As we show in our quantitative analysis, this mechanism limits the government's debt and acts as a disciplining device.

### 4.4 Secondary Markets and Link with Empirical Analysis

We have introduced a passive demand in the model in order to compute the same reduced-form elasticity of the empirical analysis in Section 3. Notice, however, that our empirical elasticity is based on high-frequency (daily) data. Specifically, we estimated this elasticity within a short window around the rebalancing of the $\mathcal{I}$ index. To address this frequency disconnect, we introduce secondary markets into our model to better capture the high-frequency nature of our empirical analysis. In particular, we consider two instances of trading in secondary markets within a period. The timing assumption is as follows:

1. *The endowment $y$ is realized. The initial states are: $\{y, \tau, B\}$*
2. *The government chooses $d(y, \tau, B)$ and $B'(y, \tau, B)$.*
3. *The primary and secondary market open. Let $q^{SM,0}(y, \tau, B')$ denote the opening price.*
4. *The next-period index weights $\tau'$ are realized. Bond prices are updated.*
5. *The secondary market closes. Let $q^{SM,1}(y, \tau', B')$ denote the closing price.*

With this simple extension, we can compute "high-frequency" bond price reactions to exogenous changes in index weights, similar to what we did in our empirical setup (i.e., price changes during a rebalancing event). The only difference between $q^{SM,1}$ and $q^{SM,0}$ arises from the update of $\tau$, since both the endowment and the stock of debt remain fixed while the secondary market is open. In Appendix C, we describe in detail the pricing functions under this extension. What it is important to note is that, absent secondary markets, the timing assumption is exactly the same as in the baseline model. This implies that the proposed extension nests our baseline model.

Let $\Delta\mathcal{T}' \equiv \mathcal{T}(\tau', B') - \mathcal{T}(\tau, B')$ denote an exogenous shift in the passive demand implied by a change in index weights. Given $\Delta\mathcal{T}'$, and by means of simulations, we can compute the same reduced-form elasticity $\hat{\eta}$ of our empirical analysis:

$$\hat{\eta} = (-)\frac{\Delta q}{\Delta\mathcal{T}'}\,\frac{B' - \mathcal{T}(\tau, B')}{q^{SM,0}(y, \tau, B')}, \tag{20}$$

where $\Delta q \equiv q^{SM,1}(y, \tau', B') - q^{SM,0}(y, \tau, B')$. We can then use the model to decompose $\hat{\eta}$ into a structural demand elasticity $\eta$ and changes in expected repayment $\alpha$. That is,

$$\hat{\eta} = \underbrace{(-)\frac{\Delta\Psi}{\Delta\mathcal{T}}\,\frac{B' - \mathcal{T}(\tau, B')}{\Psi^{SM,0}(y, \tau, B')}}_{\equiv\,\eta} + \underbrace{(-)\frac{\Delta\mathbb{E}\mathcal{R}'}{\Delta\mathcal{T}'}\,\frac{B' - \mathcal{T}(\tau, B')}{\mathbb{E}_{y',\tau'|y,\tau}\mathcal{R}(y', \tau', B')}}_{\equiv\alpha}, \tag{21}$$

where $\Delta\Psi \equiv \Psi^{SM,1}(y, \tau', B') - \Psi^{SM,0}(y, \tau, B')$ is the change in the bond price driven by the inelastic demand component before and after the new index weight $\tau'$ is realized. Similarly,

$\Delta \mathbb{E}\mathcal{R}' \equiv \mathbb{E}_{y'|y}\mathcal{R}(y', \tau', B') - \mathbb{E}_{y',\tau'|y,\tau}\mathcal{R}(y', \tau', B')$ captures the change in the bond's expected repayment once the new $\tau'$ is realized.

Two mechanisms underlying the previous decomposition are worth emphasizing. First, if the $\tau$ process is persistent, an increase in $\tau$ today influences future $\Psi(.)$ terms and, consequently, future bond prices and expected payoffs (as shown in Equations 17 and 18). Thus, even if $B'$ is fixed and default risk remains constant, changes in $\tau$ affect the bond price not only through the inelastic demand component, $\Psi(.)$, but also through future payoffs. Second, through its effects on (current and future) bond prices, changes in $\tau$ affect the government's value function $V^r(.)$ (Equation 15) and thus influence its debt and default policies, $B'(.)$ and $d(.)$, respectively. Changes in these policies, in turn, impact expected payoffs, the $\Psi(.)$ term, and the bond price (from Equations 17 and 18). This interconnectedness highlights the need for a quantitative analysis to disentangle all the forces at play.

# 5 Quantitative Analysis

## 5.1 Calibration

We calibrate the model at a quarterly frequency using data on Argentina, a benchmark case commonly studied in the sovereign debt literature. The calibration follows a two-step procedure. We first fix a subset of parameters to standard values in the literature or based on historical Argentine data. We then internally calibrate the remaining parameters to match relevant moments for Argentine spreads and other business cycle statistics.

In terms of functional forms and stochastic processes, we assume that the government has CRRA preferences: $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$, where $\gamma$ denotes the risk aversion. Output follows an AR(1) process given by $\log(y') = \rho_y \log(y) + \epsilon'_y$, with $\epsilon'_y \sim N(0, \sigma_y)$. If the government defaults, output costs are governed by a quadratic loss function $\phi(y) = \max\left\{d_0 y + d_1 y^2, 0\right\}$. For $d_0 < 0$ and $d_1 > 0$, the output cost is zero whenever $0 \leq y \leq -\frac{d_0}{d_1}$ and rises more than proportionally with $y$ when $y > -\frac{d_0}{d_1}$. This loss function is identical to the one used in Chatterjee and Eyigungor (2012) and allows us to closely match the sovereign spreads observed in the data. As for the demand of passive investors, we assume that it is proportional to the (end-of-period) amount of bonds outstanding. Specifically, $\mathcal{T}' = \mathcal{T}(\tau, B') = \tau \times B'$. We let $\tau$ follow an AR(1) process given by $\log(\tau') = (1-\rho_\tau)\log(\tau^\star) + \rho_\tau \log(\tau) + \epsilon'_\tau$, where $\epsilon'_\tau \sim N(0, \sigma_\tau)$.

Based on the analysis in Section 4.2, we consider the following functional form for the

Table 5
Calibration of the model

| Panel a: Fixed Parameters | | | Panel b: Calibrated Parameters | | |
|---|---|---|---|---|---|
| Param. | Description | Value | Param. | Description | Value |
| $\gamma$ | Risk aversion | 2.00 | $\beta$ | Discount rate | 0.951 |
| $r$ | Risk-free interest rate | 0.01 | $\bar{d}_0$ | Default cost—level | $-0.264$ |
| $\lambda$ | Debt maturity | 0.05 | $\bar{d}_1$ | Default cost—curvature | 0.31 |
| $z$ | Debt services | 0.03 | $\kappa$ | Slope parameter | 72.0 |
| $\theta$ | Reentry probability | 0.0385 | $\bar{\mathcal{A}}$ | Active investors demand | 0.455 |
| $\rho_{\mathrm{y}}$ | Output, autocorrelation | 0.93 | | | |
| $\sigma_{\mathrm{y}}$ | Output, shock volatility | 0.02 | | | |
| $\tau^{\star}$ | Share of passive demand | 0.123 | | | |
| $\rho_{\mathcal{T}}$ | FIR, autocorrelation | 0.66 | | | |
| $\sigma_{\mathcal{T}}$ | FIR, shock volatility | 0.02 | | | |

downward-slopping $\Psi(.)$ term:

$$\Psi\left(y,\tau,B'\right) = \exp\left\{-\kappa\frac{\mathbb{V}_{s'|s}\left(\mathcal{R}'(.)\right)}{\mathbb{E}_{s'|s}\left(\mathcal{R}'(.)\right)}\times\left(B'-\mathcal{T}'-\bar{\mathcal{A}}\right)\right\}, \tag{22}$$

where $\kappa \geq 0$ characterizes the elasticity of the demand function and $\bar{\mathcal{A}}$ denotes the average holdings of active investors (as determined by the fixed component of their mandates, $\xi_j^i$). For tractability, we assume time-invariant values for both $\kappa$ and $\bar{\mathcal{A}}$.[26] This specification introduces a wedge in the price of risky bonds (i.e., those with $\mathbb{V}_{s'|s}\left(\mathcal{R}'(.)\right) > 0$) and allows us to capture two key features of our empirical analysis: a downward-sloping demand for active investors and a demand elasticity that increases (in magnitude) with default risk.

Table 5 lists the calibrated parameters. For the subset of fixed parameters (Panel a), we set $\gamma = 2$, which is a standard value for risk aversion in the literature. We also set a quarterly risk-free rate of $r_f = 0.01$, in line with the average real risk-free rate observed in the United States. The probability of re-entering international markets is set to $\theta = 0.0385$, implying an average exclusion duration of 6.5 years. We set $\lambda = 0.05$ to target a debt maturity of 5 years and $\nu = 0.03$ to match Argentina's average debt services. The parameters for the endowment process, $\rho_y$ and $\sigma_y$, are based on log-linearly detrended quarterly real GDP data for Argentina. All these parameters are taken from Morelli and Moretti (2023). Last, we set $\tau^{\star}$ to match the average share of Argentina's external debt tracked by passive investors and calibrate $\rho_{\mathcal{T}}$ and $\sigma_{\mathcal{T}}$ to match the persistence and volatility of our FIR measure.

We internally calibrate the remaining parameters (Table 5, Panel b). We jointly calibrate the default cost parameters $\{d_0, d_1\}$, together with the government's discount factor $\beta$, to target Argentina's average ratio of (external) debt to GDP, average spread, and volatility

[26] As shown in Section 4.2, these terms could be, in principle, time-varying functions. We also use an exponential specification purely for computational reasons: to avoid having a negative price in some states.

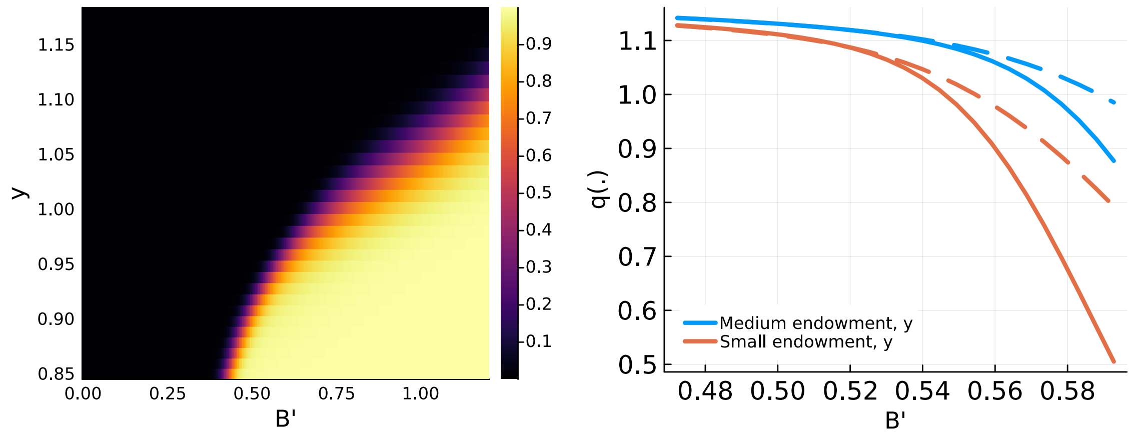
Table 6
Targeted moments

| Target | Description | Data | Model |
|---|---|---|---|
| $\mathbb{E}[SP]$ | Bond spreads | 472bp | 476bp |
| $\sigma(SP)$ | Volatility of spreads | 200bp | 135bp |
| $\mathbb{E}[B/Y]$ | Debt to output | 55% | 54% |
| $\mathbb{E}[\Psi]$ | Inconvenience yield | 1.0 | 1.002 |
| $\hat{\eta}$ | Reduced-form elasticity | $-0.3$ | $-0.29$ |

Note: The table reports the moments targeted in the calibration and their model counterpart.

Figure 4
Default set and bond prices

(a) Default set (b) Bond price



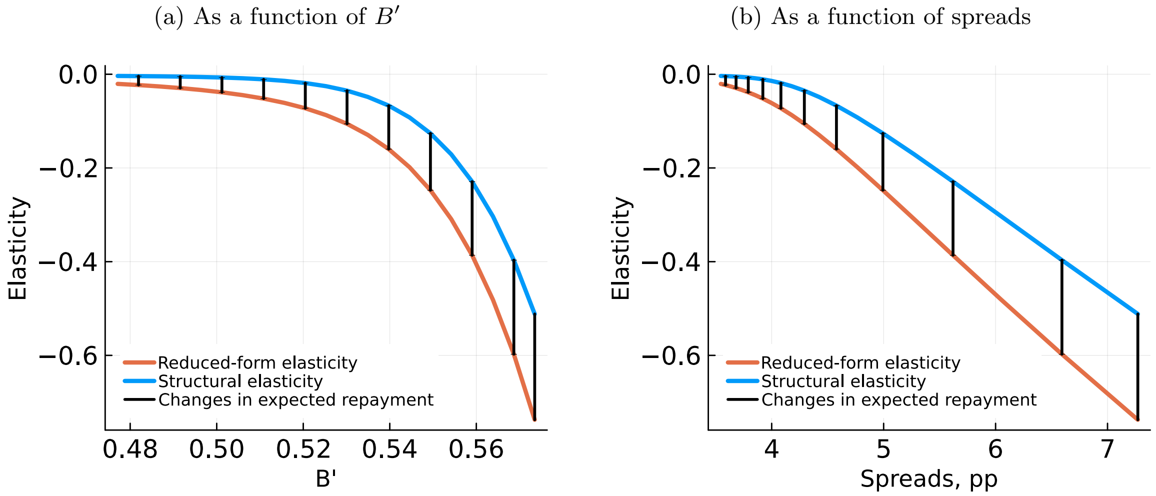

Note: Panel (a) shows the default policy for different combinations of $B'$ and $y$. The black area depicts combinations of $B'$ and $y$ such that default probability is zero. Lighter colors indicate a higher default probability. In Panel (b), the solid lines show the bond pricing kernel $q(y, \tau, B')$ for different values of $B'$ and for two values of output. The dashed lines show the bond price under a perfectly elastic demand, taking as given the same bond and repayment policies as in our baseline model (i.e., $q(.)/\Psi(.)$).

of spreads.[27] Additionally, we calibrate $\kappa$ to match the estimated (inverse) reduced-form demand elasticity, $\hat{\eta}$. Last, we set $\bar{\mathcal{A}}$ to match the average holdings of active investors. That is, $\bar{\mathcal{A}} = \bar{B} - \bar{\mathcal{T}}$, where $\bar{B}$ denotes the average debt stock and $\bar{\mathcal{T}}$ denotes passive investors' average holdings. Given Equation (22), this is equivalent to targeting an average $\Psi(.)$ of one, which implies that the (in)convenience yield is zero on average. The introduction of $\Psi(.)$ thus only affects the sensitivity of the pricing kernel to changes in $B'$ around the $\{\bar{B}, \bar{\mathcal{T}}, \bar{\mathcal{A}}\}$ point.

Figure 4 depicts the default set and the bond price function $q(.)$ for different values of $B'$ and $y$. Panel (a) shows that the government defaults in states with high debt and low output. As a consequence, the bond price is decreasing in $B'$ and increasing in $y$ (Panel (b)). The dashed lines in Panel (b) depict bond prices under a counterfactual in which we maintain

[27] Annualized spreads are computed as $SP = \left(\frac{1+i(y,\tau,B')}{1+r_f}\right)^4 - 1$, where $i(y, \tau, B')$ is the internal quarterly return rate, which is the value of $i(.)$ that solves $q(y, \tau, B') = \frac{[\lambda+(1-\lambda)\nu]}{\lambda+i(y,\tau,B')}$.

Figure 5
Disentangling the demand elasticity




Note: The figure shows the reduced-form inverse demand elasticity $\hat{\eta}$ (orange lines) and the structural one $\eta$ (blue lines). The vertical differences between the two lines (represented by the black lines) capture the endogenous changes in bonds' expected repayment, $\alpha$. Panel (a) shows the results as a function of $B'$, while Panel (b) shows the results as a function of annualized bond spreads.

the baseline $B'(.)$ policy but assume that demand is perfectly elastic (i.e., they show the $q(.)/\Psi(.)$ function). At lower $B'$ levels, where default risk is minimal, bond prices remain largely unaffected by the downward-sloping demand. However, as $B'$ increases, heightened repayment volatility decreases $\Psi(.)$, subsequently lowering the bond price $q(.)$.

## 5.2 Decomposing the Reduced-form Demand Elasticity

We formally disentangle the different channels through which changes in $\mathcal{T}$ affect bond prices. As shown in Equation (21), index rebalancing affects bond prices through two mechanisms: (i) the (inverse) structural demand elasticity of active investors, $\eta$, and (ii) changes in expected repayment, $\alpha$. Using the calibrated model, we can isolate the effects driven by changes in expected repayment to properly identify the structural demand elasticity.

Figure 5 decomposes the channels outlined in Equation (21). The black line shows the reduced-form (inverse) demand elasticity $\hat{\eta}$, while the blue line depicts the model-implied structural elasticity, $\eta$. The vertical differences between these two curves (red lines) indicate the portion of the reduced-form elasticity attributable to endogenous changes in the repayment function, $\alpha$. We find that the magnitude of $\hat{\eta}$ is always higher than that of $\eta$. The difference can be substantial, particularly for larger values of $B'$ and for higher bond spreads. The first column of Table 5 shows the unconditional average for both the reduced-form elasticity, $\hat{\eta}$, and the structural elasticity, $\eta$. On average, the structural elasticity accounts for less than two-thirds of the reduced-form elasticity.

Table 7
Persistence of shocks and demand elasticity

| Moment | Baseline | Lower persistence | Low persistence | Higher persistence |
|---|---|---|---|---|
| Reduced-form $\hat{\eta}$ | -0.29 | -0.24 | -0.26 | -0.32 |
| Structural $\eta$ | -0.17 | -0.18 | -0.17 | -0.17 |
| Bias, $1-\eta/\hat{\eta}$ | 40% | 25% | 34% | 48% |

Note: The table compares the reduced-form inverse demand elasticity $\hat{\eta}$ with the structural one $\eta$. The "Baseline" column shows the elasticities under our baseline calibration. In the "Lower persistence" case, we decrease the persistence of the $\{\tau\}$ process by setting $\rho_\tau = 0.25$. The "Low persistence" column is based on $\rho_\tau = 0.50$. The "Higher persistence" column shows the results for $\rho_\tau = 0.80$.

The magnitudes of the documented biases critically depend on the persistence of the $\tau$ process. The last two columns of Table 7 compare the reduced-form and structural elasticities for different persistence values of the $\{\tau\}$ process. When the process is more (less) persistent, the structural elasticity accounts for a smaller (larger) share of the reduced-form elasticity. In other words, the more persistent the shock, the smaller the total price response attributed to the inelastic component of investors' demand. In Appendix C.4, we analyze these biases in more detail.

Overall, our analysis highlights the importance of accounting for issuers' endogenous responses to an exogenous (supply-shifting) shock and the resulting changes in assets' expected repayment. Neglecting these factors can introduce significant biases into the estimated demand elasticity, particularly if the shock is persistent. As argued in Section 3, our FIR measure is inherently more temporary than other supply-shifting instruments used in the literature, such as index additions or deletions. However, even in this case, the bias can represent over one-third of the reduced-form elasticity.

### 5.3 Implications of a Downward-sloping Demand

As illustrated in Equation (19), in determining its optimal debt policy, the government internalizes not only the effects of a higher $B'$ on $q(.)$ through changes in its default probability but also the effects through the inelastic demand. This section quantifies the implications of a downward-sloping demand on bond prices, default risk, and government policies. To this end, we compare our downward-sloping demand model with an alternative scenario where investors are perfectly elastic.

Table 8 reports a set of targeted and untargeted moments for our baseline model and for an alternative case with a perfectly elastic demand ($\kappa = 0$). All the other model parameters remain the same. Despite similar levels of debt, we find that the default frequency and average spreads are *lower* in the case of inelastic demand compared to the perfectly elastic

Table 8
Comparison with perfectly elastic case: Unconditional moments

| Moment | Description | Baseline | Perfectly elastic |
|---|---|---|---|
| $\mathbb{E}\,(SP)$ | Bond spreads | 476bp | 910bp |
| $\sigma\,(SP)$ | Volatility of spreads | 135bp | 466bp |
| $\mathbb{E}\,(B/y)$ | Debt to output | 54% | 52% |
| $\mathbb{E}\,(d)$ | Default frequency | 3.84% | 4.74% |
| $\sigma(B)/\sigma(y)$ | Standard deviation of debt, relative to output | 1.06 | 1.84 |
| $\rho\,(\Delta B, y)$ | Correlation between issuances and output | 0.37 | 0.51 |
| $\rho\,(SP, y)$ | Correlation between spreads and output | -0.68 | -0.51 |

Note: The table compares a set of moments between our baseline model with inelastic investors and a counterfactual scenario in which investors are perfectly elastic ($\kappa = 0$).

scenario.

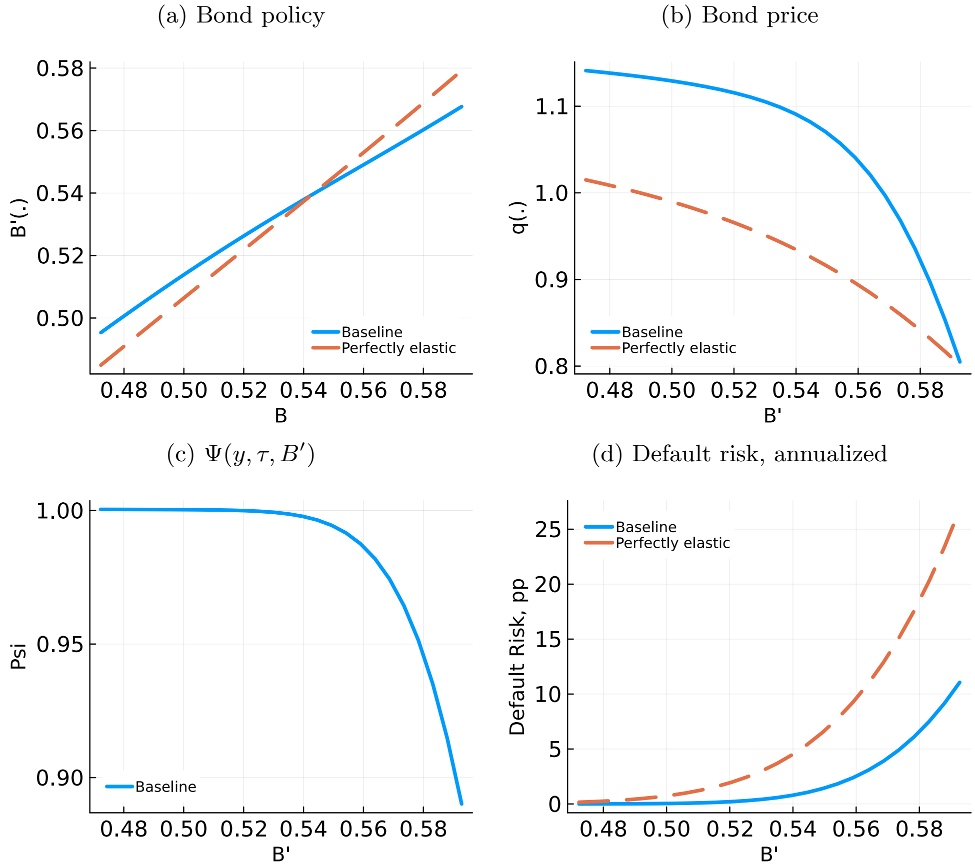
Two factors explain the lower default rate and bond spreads. First, the government's debt policy is directly influenced by the downward-sloping demand. Panel (a) of Figure 6 shows the optimal debt policy $B'(y, \tau, B)$ in our baseline model and in the perfectly elastic case. For large values of $B$ (in states where $\mathbb{V}\,(\mathcal{R}'(.))$ is high), an additional unit of $B'$ reduces the bond price $q(.)$ due to both higher default risk and investors' inelastic behavior. As a result, the government does not find it optimal to issue large amounts of debt because the associated costs are too high. An inelastic demand thus imposes a limit to the maximum amount of debt that a government is willing to issue.

Second, these changes in the optimal bond policy have important effects on the pricing of bonds (Figure 6, Panel (b)). For small values of $B'$ (low default risk), $q(.)$ is actually *higher* than in the perfectly elastic case. As shown in Panel (c), this larger bond price is not driven by a convenience yield; given our calibration, $\Psi(.)$ is typically smaller than one. Instead, the higher bond price results from a lower default risk (Panel (d)), which is a direct consequence of the government's reduced incentives to issue large amounts of $B'$.

Overall, an inelastic demand diminishes a government's incentives to issue additional units of debt, acting as a disciplining device that reduces default risk and increases bond prices.

How does an inelastic demand affect the optimal government response to shocks? It is well-known that in models with limited commitment and endogenous default, the optimal bond policy is pro-cyclical (Arellano, 2008). While the government would like to issue more debt in "bad" times (i.e., when output is low) to smooth consumption, the resulting increase in spreads—due to higher default risk— leads the government to actually reduce its debt. On the other hand, in "good" times (when output is high and default risk is low), the government

Figure 6
Comparison with perfectly elastic case: Policy functions and prices



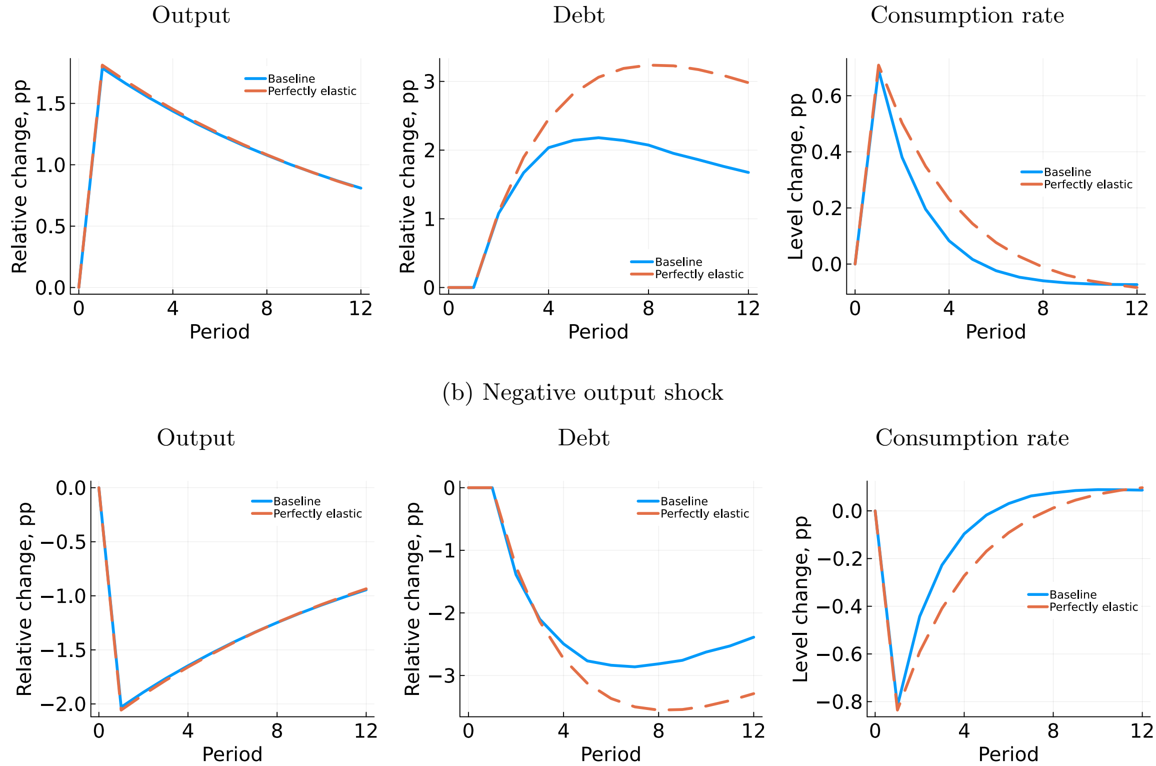

Note: The top panel presents bond policies and prices as a function of $B$ and $B'$, respectively. We evaluate all the functions at the mean value for output, $y$. Blue solid lines show the results for our baseline model with inelastic investors and the orange dashed lines show the results in an alternative model in which investors are perfectly elastic. The bottom panel depicts the $\Psi(y, \tau, B')$ function and the annualized default risk.

benefits from cheaper credit and increases its debt issuance. This standard mechanism in sovereign debt models explains the well-known excess volatility of consumption in emerging markets.

We find that this pro-cyclicality is dampened in the presence of inelastic investors. In Figure 7, we analyze the impulse responses to endowment shocks. For a positive shock (Panel a), the figure shows a greater increase in debt issuance when investors are perfectly elastic. Under a perfectly elastic demand, the government can take full advantage of the lower financing costs associated with the implied decrease in default risk. Under inelastic demand, however, the government response is muted, as it internalizes that, despite the cheaper financing, an additional unit of debt reduces bond prices due to the downward-sloping demand. In this sense, the inelasticity imposes a cost: it prevents the government from issuing more during periods when financing is cheap, which lowers the expansion in consumption. For a negative endowment shock (Panel b), a similar pattern emerges. A lower output increases borrowing costs, prompting the government to decrease its debt. However, under inelastic demand, reducing the stock of debt decreases the inconvenience yield demanded by investors, which lowers spreads; hence, the contraction in debt is less pronounced.

Figure 7
Impulse responses to an output shock

(a) Positive output shock



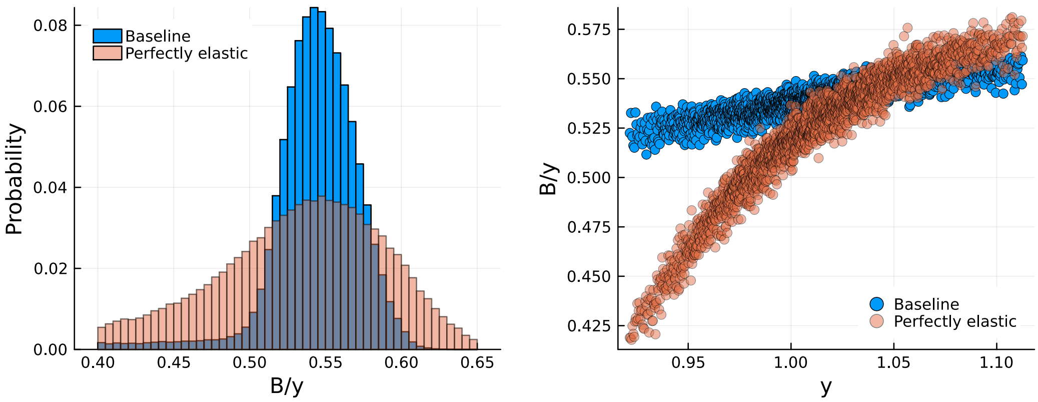

Note: Figure shows the impulse response dynamics to a positive (panel a) and negative (panel b) endowment shock. Blue lines show the dynamics for our baseline model with inelastic investors. The orange dashed lines show the perfectly elastic case.

Figure 8 compares the unconditional distribution of debt-to-output ratios between our baseline model and the perfectly elastic case. Under an inelastic demand, this distribution is significantly less dispersed (Panel a). In fact, the standard deviation of debt is about 30% smaller under inelastic investors (as shown in Table 8). In line with the impulse response dynamics, the debt-to-output ratio exhibits a smaller unconditional correlation with output when investors are inelastic (Panel b). This, in turn, results in a larger correlation (in magnitude) between spreads and output (Table 8).

We conclude our analysis by examining the welfare implications of an inelastic demand. We define the certainty equivalent consumption (CEC) as the proportional increase in consumption under the perfectly elastic case, such that the household is indifferent between

Figure 8
Stock of sovereign debt under inelastic investors

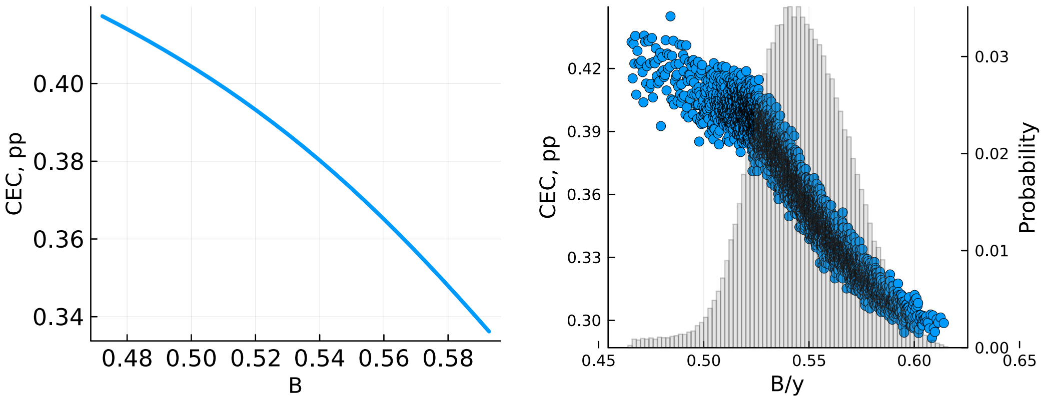
(a) Distribution of $B/y$ (b) Relation with output




Note: Panel (a) shows the model simulated distributions for debt-to-output. Panel (b) shows a binscatter plot between the debt-to-output ratio and output. Blue bars and dots are for the baseline model with inelastic investors. Orange bars and dots are for an alternative model in which investors are perfectly elastic.

Figure 9
Inelastic investors: Welfare analysis

(a) CEC as a function of $B$ (b) CEC based on model simulations




Note: The figure shows the certainty equivalent consumption (CEC) defined as the proportional increase in consumption under the perfectly elastic counterfactual such that the household is indifferent between that case and the inelastic one. Panel (a) shows the CEC across different levels of $B$. The blue dots in Panel (b) show the the relation between the CEC and debt-to-output ratio $B/y$, based on model simulations. The gray bars show the histogram for the distribution of $B/y$.

this scenario and the inelastic one.[28] Figure 9 displays the results. We find a positive CEC, indicating that the disciplining device is sufficiently strong for the household to prefer a world with inelastic investors. The CEC decreases as the stock of debt increases due to the higher inconvenience yield demanded by investors (as shown in Figure 6).

[28]The CEC is implicitly defined as the value of $\tilde{x}$ such that $\sum_{t=0}^{\infty}\beta^t\mathbb{E}_t u(c_t) = \sum_{t=0}^{\infty}\beta^t\mathbb{E}_t u\left((1+\tilde{x})\,\tilde{c}_t\right)$, where $c_t$ denotes the consumption under an inelastic demand and $\tilde{c}_t$ denotes the consumption under a perfectly elastic case. By exploiting the power utility function, the CEC is given by: $\tilde{x} = \left[\frac{V(y,\tau,B)}{\tilde{V}(y,\tau,B)}\right]^{\frac{1}{1-\gamma}} - 1$, where $\tilde{V}(.)$ is the government's value function under the perfectly elastic case.

# 6 Conclusion

In this paper, we present evidence of downward-sloping demand curves in risky sovereign debt markets and analyze their implications for the optimal supply of sovereign bonds. Our approach combines high-frequency bond-level price reactions to well-identified shocks with a structural model that features endogenous debt issuance and default risk. This methodology allows us to isolate endogenous changes in expected bond payoffs behind the estimated price reactions and to back out a structural demand elasticity. Empirically, we find that a 1 p.p. reduction in the effective bond supply leads to a 30 basis point increase in bond prices. Our structural model reveals that over one-third of this response is attributable to endogenous changes in the expected repayment of bonds. We show that an inelastic demand can have important macroeconomic effects. In particular, we find that the inelastic demand influences and shapes government policies regarding optimal debt issuance and default. By diminishing the government's incentives to issue additional units of debt, an inelastic demand acts as a disciplining device that reduces both default risk and borrowing costs. Moreover, we find that the pro-cyclicality of the debt policy is dampened in the presence of inelastic investors.

Our results highlight the importance of considering issuers' endogenous responses and the resulting changes in expected asset payoffs. Failing to account for these responses can introduce significant biases when estimating demand elasticities, particularly for risky assets. Our paper can lead to further research along several dimensions. For instance, given the model predictions, it would be interesting to empirically study the impact of inelastic demand on government debt issuance. More importantly, our framework can be extended to other assets and markets, notably equity and corporate bonds. The endogenous responses that we emphasize in this paper can be applied to other issuers of risky assets, which we leave for future research.

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# Supplemental Appendix for Inelastic Demand Meets Optimal Supply of Risky Sovereign Bonds

## A Diversification Methodology

Relative to a market capitalization-weighted index, the EMBIGD employs a diversification methodology to produce a more even distribution of country weights. This ensures that countries with large market capitalization do not dominate the index. To achieve this goal, the methodology restricts the weights of countries with above-average debt levels by including only a portion of their outstanding debt.

The methodology is anchored on the average country face amount in the index, called Index Country Average (ICA), and defined as:

$$ICA_t = \sum_{c=1}^{C} \frac{FA_{c,t}}{C},$$

where $FA_{c,t}$ denotes country $c$'s bond face amount included in the index at time $t$, and $C$ denotes the number of countries in the index.

The diversified face amount for any country in the index is derived according to the following rule:

1. The maximum threshold is determined by the country with the largest face amount ($FA_{max}$), capped at twice the ICA ($ICA \times 2$).

2. If a country's face amount is between the ICA and $FA_{max}$, its diversified face amount is linearly interpolated.

3. If a county's face amount is below the ICA, the entire face amount is eligible for inclusion.

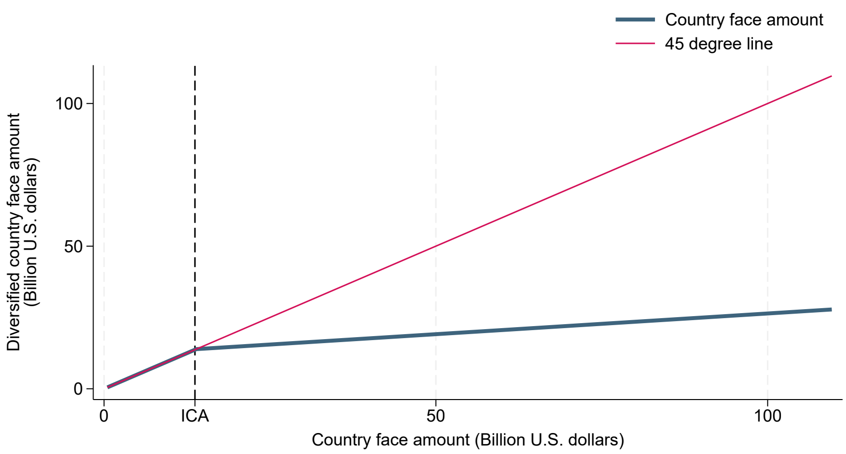
The diversified country face amount ($DFA_{c,t}$) is calculated as follows:

$$DFA_{c,t} = \begin{cases} ICA_t \times 2 & \text{if } FA_{c,t} = FA_{max,t} \\ ICA_t + \frac{ICA_t}{FA_{max_t} - ICA_t} \left( FA_{c,t} - ICA_t \right) & \text{if } FA_{c,t} > ICA_t \\ FA_{c,t} & \text{if } FA_{c,t} \leq ICA_t \end{cases} \tag{A1}$$

For countries with a restricted face amount in the EMBIGD, the proportional decrease applied to the country-level face amount is also applied to their respective bonds. The diversified market value is calculated by multiplying the diversified face amount by the bond price. The diversified weight of each bond is determined by its share of the total diversified market capital in the index.

Additionally, country weights are capped at 10%. Any excess weight above this cap will be redistributed pro rata to smaller countries below the cap, across all bonds from countries not capped at 10%. Appendix Figure A1 compares the country-level diversified and non-diversified face amount for December 2018.

Appendix Figure A1
Effect of the diversification methodology on the country face amount




Note: The figure illustrates the differences between the country-level face amount and their diversified versions, which the EMBIGD uses to generate the diversified bond weights. The data used are from December 2018. Sources: J.P. Morgan Markets, and authors' calculations.

# B A Model of Inelastic Investors

In this appendix, we first provide additional material and derivations for the analysis in Section 4.2. We then describe microfoundations for the assumed demand structure, analyzing two related cases. In the first one, the inelasticity comes from investor risk aversion, while the second case is rooted in a Value-at-Risk (VaR) constraint to which investors are subject.

## B.1 Additional Derivations

From Equation (9) in the main text, and based on a first-order approximation for the elastic component of the demand $e^{\kappa_j \hat{\pi}_{i,t}}$ around $\bar{\pi}_i$, we can write the market-value demand of active investors as follows:

$$\tilde{\mathcal{A}}_t^i = \sum_j \left(1 - \Lambda_j \bar{\pi}_i\right) W_{j,t} \theta_j \xi_j^i e^{\Lambda_j \bar{\pi}_i} + \hat{\pi}_{i,t} \sum_j \Lambda_j W_{j,t} \theta_j \xi_j^i e^{\Lambda_j \bar{\pi}_i}. \tag{B1}$$

The first term captures investors' average purchases of bond $i$, which are given by their exogenous mandates $\xi_j^i$. The second term captures deviations from those purchases (i.e., the elastic component of the demand), which is a function of $\hat{\pi}_{i,t}$.

For the remainder of the analysis, we focus on the case in which $\hat{\pi}_{i,t}\left(r_{t+1}^i\right) = \frac{\mathbb{E}_t\left(r_{t+1}^i\right)}{\mathbb{V}_t\left(r_{t+1}^i\right)}$. Define $\mathcal{R}_{t+1}^i$ as the next-period repayment per unit of the bond so that $r_{t+1}^i \equiv \frac{\mathcal{R}_{t+1}^i}{q_t^i} - r_f$, where $r_f$ denotes the risk-free rate. We can then write $\hat{\pi}_{i,t}\left(r_{t+1}^i\right) = q_t^i \frac{\mathbb{E}_t \mathcal{R}_{t+1}^i - q_t^i r_f}{\mathbb{V}_t \mathcal{R}_{t+1}^i}$. Without loss of generality, consider a case where $\bar{\pi}_i$ is close to zero. After substituting these expressions into the equation, we can rewrite Equation (B1) as follows:

$$\tilde{\mathcal{A}}_t^i = q_t^i \bar{\mathcal{A}}_t^i + q_t^i \left(\frac{\mathbb{E}_t \mathcal{R}_{t+1}^i - q_t^i r_f}{\mathbb{V}_t \mathcal{R}_{t+1}^i}\right) \sum_j \Lambda_j W_{j,t} \theta_j \xi_j^i, \tag{B2}$$

where $\bar{\mathcal{A}}_t^i$ is defined such that $q_t^i \bar{\mathcal{A}}_{t+1}^i = \sum_j W_{j,t} \theta_j \xi_j^i$. We can interpret $\bar{\mathcal{A}}_t^i$ as active investors' holdings aimed at satisfying the fixed part of their mandates.

As for the demand of passive investors, let $M_t$ denote the market value of the index $\mathcal{I}$ and define $S_t^i$ as bond $i$'s face amount included in this index. For simplicity, assume that bond $i$ is only included in index $\mathcal{I}$. Then, $w_t^i = \frac{S_t^i q_t^i}{M_t}$, and we can write the market-value passive demand as

$$\tilde{\mathcal{T}}_t^i = q_t^i S_t^i \sum_j \frac{W_{j,t}\left(1 - \theta_j\right)}{M_t} = q_t^i \mathcal{T}_t^i, \tag{B3}$$

where $\mathcal{T}_t^i \equiv S_t^i \sum_j \frac{W_{j,t}(1-\theta_j)}{M_t}$ denotes the face amount of bond $i$'s passive holdings.

After replacing Equations (B2) and (B3) in the market-clearing condition (Equation (10) in the main text), we obtain a closed-form solution for the bond price:

$$q_t^i = \frac{\mathbb{E}_t\left(\mathcal{R}_{t+1}^i\right)}{r_f}\left[1-\kappa_t^i\frac{\mathbb{V}_t\left(\mathcal{R}_{t+1}^i\right)}{\mathbb{E}_t\left(\mathcal{R}_{t+1}^i\right)}\left(B_t^i-\mathcal{T}_t^i-\bar{\mathcal{A}}_t^i\right)\right], \tag{B4}$$

where $\kappa_t^i(\mathbf{\Lambda}) \equiv \frac{1}{\sum_j \Lambda_j W_{j,t}\theta_j \xi_j^i}$ parameterizes the downward-slopping behavior of the demand. It is a weighted average of investors' $\{\Lambda_j\}$ parameters, where the weights are given by the amount that each investor allocates on bond $i$.

Next, we show that we can obtain an analogous pricing kernel under risk-averse investors or under risk-neutral investors subject to a standard VaR constraint.

## B.2 Microfoundation Based on Risk-Averse Investors

Consider a case where investors are risk averse and have mean-var preferences. They care about both the total return of their portfolio and their return relative to a benchmark index $\mathcal{I}$ they track. Additionally, they are heterogeneous and differ in their degree of risk aversion and how their compensation depends on their total and relative return. Following the same notation as in the main text, let $j = \{1, ..., J\}$ denote the investor type. Let $i = \{1, ..., N\}$ denote the set of bonds that are part of the $\mathcal{I}$ index, and let $\boldsymbol{w}_t = \left\{w_t^1, ..., w_t^N\right\}$ be the vector of index weights for each constituent bond. The vector $\boldsymbol{r}_{t+1} = \left\{r_{t+1}^1, ..., r_{t+1}^N\right\}$ denotes the next-period (gross) returns (i.e., the bond gross return in excess of the risk-free rate, $r^f$). Last, let $\boldsymbol{B}_t = \left\{B_t^1, ..., B_t^N\right\}$ denote the bond supply.

For an investor $j$, their total compensation is a convex combination between the return of their portfolio and the relative return versus the index $\mathcal{I}$. Let $\boldsymbol{x}_{j,t} = \left\{x_{j,t}^1, ..., x_{j,t}^N\right\}$ be investor $j$'s vector of portfolio weights. The investor's compensation is

$$\begin{aligned} TC_{j,t} &= \theta_j\left(\boldsymbol{x}_{j,t}\right)' \cdot \boldsymbol{r}_{t+1} + \left(1-\theta_j\right)\left(\boldsymbol{x}_{j,t}-\boldsymbol{w}_t\right)' \cdot \boldsymbol{r}_{t+1} \\ &= \left[\boldsymbol{x}_{j,t} - \left(1-\theta_j\right)\boldsymbol{w}_t\right]' \cdot \boldsymbol{r}_{t+1}, \end{aligned}$$

where $\theta_j$ captures the weight of relative returns on the compensation.

Each investor chooses a combination of portfolio weights $\boldsymbol{x}_{j,t}$ to maximize $\mathbb{E}_t\left(TC_{j,t}\right) - \frac{\sigma_j}{2}\mathbb{V}_t\left(TC_{j,t}\right)$, where $\sigma_j$ captures the investor's risk aversion. In matrix form, we can write this problem as follows:

$$\mathrm{Max}_{\boldsymbol{x}_j}\left[\boldsymbol{x}_{j,t}-\left(1-\theta_j\right)\boldsymbol{w}_t\right]'\boldsymbol{\mu}_t - \frac{\sigma_j}{2}\left[\boldsymbol{x}_{j,t}-\left(1-\theta_j\right)\boldsymbol{w}_t\right]'\boldsymbol{\Sigma}_t\left[\boldsymbol{x}_{j,t}-\left(1-\theta_j\right)\boldsymbol{w}_t\right],$$

where $\boldsymbol{\mu}_t \equiv \mathbb{E}_t\left(\boldsymbol{r}_{t+1}\right)$ denotes the expected excess return of the portfolio and $\boldsymbol{\Sigma}_t \equiv \mathbb{V}_t\left(\boldsymbol{r}_{t+1}\right)$ denotes the variance-covariance matrix of excess returns. The optimal portfolio allocation for investor $j$ is given by

$$\boldsymbol{x}_{j,t} = \frac{1}{\sigma_j} \boldsymbol{\Sigma}_t^{-1} \boldsymbol{\mu}_t + (1 - \theta_j)\, \boldsymbol{w}_t. \tag{B5}$$

The first term on the right-hand side of Equation (B5) captures the usual mean-variance portfolio. An analogous expression can also be derived under CARA preferences (see, e.g., Pavlova and Sikorskaya, 2022). The second term reflects the reluctance of some investors to deviate from the benchmark portfolio, $\boldsymbol{w}$, indicating an inherently inelastic demand. It is not a function of the expected return or riskiness of the bonds; rather, it depends only on how much investors penalize deviations from the benchmark. Purely passive investors (i.e., those with $\theta_j = 0$ and $\sigma_j \to \infty$) never deviate from the benchmark portfolio and exhibit a perfectly inelastic demand.

Let $W_{j,t}$ denote the wealth of each type of investor $j$. Then $B^i_{j,t} = \frac{W_{j,t} x^i_{j,t}}{q^i_t}$ are investor $j$'s purchases of bond $i$, where $q^i_t$ denotes the bond price. For each bond $i$, its market-clearing condition is $q^i_t B^i_t = \sum_j W_{j,t} x^i_{j,t}$. After replacing these with the investors' optimal portfolio weights, the market-clearing conditions are given by

$$\begin{aligned} \begin{bmatrix} q^1_t B^1_t \\ \vdots \\ q^N_t B^N_t \end{bmatrix} &= \sum_j W_{j,t} \left[ \frac{1}{\sigma_j} \boldsymbol{\Sigma}_t^{-1} \boldsymbol{\mu}_t + (1 - \theta_j)\, \boldsymbol{w}_t \right] \\ &= \tilde{\boldsymbol{\mathcal{A}}}_t + \tilde{\boldsymbol{\mathcal{T}}}_t, \end{aligned} \tag{B6}$$

where $\tilde{\boldsymbol{\mathcal{A}}}_t \equiv \sum_j W_{j,t} \frac{1}{\sigma_j} \boldsymbol{\Sigma}_t^{-1} \boldsymbol{\mu}_t$ denotes the active component of investors' demand (at market value). Since investors are risk averse, $\tilde{\mathcal{A}}^i_t$ is downward sloping and is a function of the expected return of bond $i$ and its variance-covariance matrix. The term $\tilde{\boldsymbol{\mathcal{T}}}_t \equiv \boldsymbol{w}_t \sum_j W_{j,t} (1 - \theta_j)$ denotes the passive demand (at market value).

Take the market-clearing condition of Equation (B6), and assume for simplicity only two assets. For ease of exposition, consider that bond $i$ is risky and bond $-i$ is not. Under these assumptions, the price for bond $i$ is given by

$$q^i_t = \frac{\mathbb{E}_t \left( \mathcal{R}^i_{t+1} \right)}{r^f} \times \Psi^i_t, \tag{B7}$$

where $\mathcal{R}^i_{t+1}$ denotes the bond's next-period repayment per unit and $\Psi^i_t$ captures the downward-sloping nature of the demand. $\Psi^i_t$ is given by

$$\Psi^i_t \equiv 1 - \kappa^{\mathrm{RA}}_t \frac{\mathbb{V}_t \left( \mathcal{R}^i_{t+1} \right)}{\mathbb{E}_t \left( \mathcal{R}^i_{t+1} \right)} \left( B^i_t - \mathcal{T}^i_t \right), \tag{B8}$$

where $1/\kappa^{\mathrm{RA}}_t \equiv \sum_j \frac{W_{j,t}}{\sigma_j}$ denotes the weighted-average risk aversion coefficient and $\mathcal{T}^i_t \equiv \tilde{\mathcal{T}}^i_t / q^i_t$

denotes the (face amount) holdings of passive investors.

Note that the bond price in Equation (B8) is analogous to the one in Equation (B4). The key difference is that with risk-averse lenders, the price elasticity is captured only by investors' risk aversion. In our main analysis, we do not specify the underlying mechanism driving this elasticity.

### B.3 Microfoundation Based on a VaR Constraint

An identical expression can also be derived for investors who are risk neutral and subject to a VaR constraint. These constraints are common both in the literature and in the regulatory sphere (e.g., Miranda-Agrippino and Rey, 2020).[29]

Consider an analogous setup to the one in the previous subsection. Investors are heterogeneous and care about their absolute and relative return with respect to index $\mathcal{I}$. They are also risk neutral and subject to a VaR constraint that imposes an upper limit on the amount of risk they can take. In particular, the problem for investor $j$ can be written as

$$\begin{aligned} \mathrm{Max}_{\{x^1_{j,t+1},\ldots x^N_{j,t+1}\}}\ & \mathbb{E}_t\Big( \left[\boldsymbol{x}_{j,t+1} - (1-\alpha_j)\, \boldsymbol{s}_{t+1}\right]' \cdot \boldsymbol{r}_{t+1} \Big) \\ \text{subject to}\ \ & \varPhi^2 \mathbb{V}_t\Big( \left[\boldsymbol{x}_{j,t+1} - (1-\alpha_j)\, \boldsymbol{s}_{t+1}\right]' \cdot \boldsymbol{r}_{t+1} \Big) - 1 \leq 0, \end{aligned}$$

where the parameter $\varPhi^2$ captures the intensity of the risk constraint. We view $\varPhi^2$ as a regulatory parameter that limits the amount of risk that an investor can take. Let $\varrho_j$ denote the Lagrange multiplier associated with the VaR constraint. It can be shown that the optimal portfolio is given by

$$\boldsymbol{x}_{j,t} = \frac{1}{\varrho_j \varPhi^2} \boldsymbol{\Sigma}_t^{-1} \boldsymbol{\mu}_t + (1-\theta_j)\, \boldsymbol{w}_t. \tag{B9}$$

The previous optimal portfolio is identical to that of Equation (B5), with the only difference being that the risk-aversion parameter $\sigma$ has been replaced by the product of the Lagrange multiplier $\varrho_j$ and the regulatory parameter $\varPhi^2$. Following the same steps as before, we can then derive an analogous pricing kernel to that of Equations (B7) and (B8). That is,

$$q_t^i = \frac{\mathbb{E}_t\left(\mathcal{R}^i_{t+1}\right)}{r^f} \left[1 - \kappa_t^{\mathrm{VaR}} \frac{\mathbb{V}_t\left(\mathcal{R}^i_{t+1}\right)}{\mathbb{E}_t\left(\mathcal{R}^i_{t+1}\right)} \left(B_t^i - \mathcal{T}_t^i\right)\right], \tag{B10}$$

where $1/\kappa_t^{\mathrm{VaR}} \equiv \sum_j \frac{W_{j,t}}{\lambda_j \varPhi^2}$ denotes the (weighted-average) intensity for which the VaR constraint binds in the aggregate.

[29] Adrian and Shin (2014) provide a microfoundation for VaR constraints. Gabaix and Maggiori (2015) use a similar constraint, in which a financier's outside option is increasing in the size and variance of its balance sheet.

# C Quantitative Model

In this appendix, we provide additional details for the quantitative model of sections 4 and 5.

## C.1 Introducing Secondary Markets

The empirical elasticity computed in Section 3 exploits exogenous variation in the passive demand in a small window around announcements of changes in the EMBIGD weights. To tightly link our model with the empirical analysis, our baseline model in Section 4 already incorporates a passive demand and exogenous changes in index weights, $\tau$. There is, however, a frequency disconnect in the sense that the model is calibrated at quarterly frequency, making it unsuitable for quantifying high-frequency price reactions to changes in $\tau$.

To address this frequency disconnect, we introduce secondary markets in the model. This extension allows us to capture the high-frequency nature of our empirical elasticity. We consider two instances of trading in secondary markets within each period: before and after the realization of the index weights, $\tau'$. The timing assumption is as follows:

1. *The endowment $y$ is realized. The initial states are: $\{y, \tau, B\}$*
2. *The government chooses $d(y, \tau, B)$ and $B'(y, \tau, B)$.*
3. *The primary and secondary market open. Let $q^{SM,0}(y, \tau, B')$ denote the opening price.*
4. *The next-period index weights $\tau'$ are realized.*
5. *The secondary market closes. Let $q^{SM,1}(y, \tau', B')$ denote the bond closing price.*

The first trading instance ($SM_0$) occurs at the beginning of the period, immediately after the government announces its default and debt choices. The bond price in this instance is given by

$$q^{SM,0}(y, \tau, B') = \beta^{\star}\mathbb{E}_{y',\tau'|y,\tau}\mathcal{R}\left(y', \tau', B'\right)\ \Psi^{SM,0}\left(y, \tau, B'\right). \tag{C1}$$

The term $\mathbb{E}_{y',\tau'|y,\tau}\mathcal{R}(y', \tau', B')$ represents the expected next-period repayment of the bond, conditional on the information available when the secondary market opens. Following the derivation in Section 4.2 (see Equation (12)), the downward-sloping component of the price function is

$$\Psi^{SM,0}\left(y, \tau, B'\right) = 1 - \kappa_0 \frac{\mathbb{V}_{\{y',\tau'\}|\{y,\tau\}}\mathcal{R}\left(y', \tau', B'\right)}{\mathbb{E}_{\{y',\tau'\}|\{y,\tau\}}\mathcal{R}\left(y', \tau', B'\right)}\left(B' - \mathcal{T}\left(\tau, B'\right) - \bar{\mathcal{A}}\right) \tag{C2}$$

Notice that $q^{SM,0}(y, \tau, B')$ coincides with the price in the primary market $q(y, \tau, B')$, which is the price relevant to the government.

The second trading instance ($SM_1$) occurs at the end of the period, when the secondary markets closes and after the new index weights $\tau'$ are realized. In this case, the bond price is

$$q^{SM,1}\left(B',y,\tau'\right)=\beta^{\star}\mathbb{E}_{y'|y}\mathcal{R}\left(y',\tau',B'\right)\Psi^{SM,1}\left(y,\tau',B'\right). \tag{C3}$$

The term $\mathbb{E}_{y'|y}\mathcal{R}\left(y',\tau',B'\right)$ is the expected next-period repayment of the bond, conditional on the information available when the secondary market closes. This term is analogous to the one in Equation (C1), but incorporates the information provided by the realization of $\tau'$. Similarly, the downward-sloping component of the price function is given by

$$\Psi^{SM,1}\left(y,\tau',B'\right)\equiv 1-\kappa_0\frac{\mathbb{V}_{y'|y}\mathcal{R}\left(y',\tau',B'\right)}{\mathbb{E}_{y'|y}\mathcal{R}\left(y',\tau',B'\right)}\left(B'-\mathcal{T}\left(\tau',B'\right)-\bar{\mathcal{A}}\right). \tag{C4}$$

Notice that, the only difference between $q^{SM,1}$ and $q^{SM,0}$ arises from the update of $\tau'$ since both the endowment and the stock of debt remain fixed while the secondary market is open. Moreover, in the absence of secondary markets, the timing assumption is exactly the same as in the baseline model.

### C.2 Definition of Equilibrium

A Recursive Markov Equilibrium is a collection of value functions $\left\{V\left(\cdot\right),V^{r}\left(\cdot\right),V^{d}\left(\cdot\right)\right\}$; policy functions $\left\{d\left(\cdot\right),B'\left(\cdot\right)\right\}$; and bond prices $q\left(\cdot\right)$ such that:

1. Taking as given the bond price function $q(.)$, the government's policy functions $B'\left(\cdot\right)$ and $d\left(\cdot\right)$ solve the optimization problem in Equations (14), (15), and (16), and $V\left(\cdot\right)$, $V^{r}\left(\cdot\right)$, and $V^{d}\left(\cdot\right)$ are the associated value functions.

2. Given $B'\left(\cdot\right)$ and $d\left(\cdot\right)$, the repayment function $\mathcal{R}'(.)$ satisfies Equation (18).

3. Taking the repayment function as given, bond prices $q(.)$ are consistent with Equation (17).

### C.3 Solution Method

We employ a global solution method to solve our quantitative model. We discretize the output process $y$ and the process for the passive demand share $\tau$ using Tauchen's method. We select 31 gridpoints for $y$ and 15 for $\tau$. As for $B$, we construct a grid consisting of 250 equally spaced points between $\underline{B}=0$ and $\overline{B}=1.2$. We ensure that $\overline{B}$ is sufficiently large (approximately three times the average stock of debt) so that it never binds in our simulations. The steps of the algorithm are as follows:

1. We start with a guess for the value functions $V^r(y,\tau,B)$ and $V^d(y)$. We also guess the bond price function $q(y,\tau,B')$ as a function of the end-of-period stock of debt, $B'$.

2. Based on these guesses, we solve for the optimal bond policy $B'(y,\tau,B)$, as described in Equation (15). To this end, we use an optimizing algorithm based on Brent's method and employ cubic splines to interpolate the value functions and bond prices when evaluating off-grid points. Given $B'(y,\tau,B)$, we then update $V^r(y,\tau,B)$.

3. We compute the value function for the case in which the government defaults in the current period, $V^d(y)$, as given by Equation (16).

4. We solve for the government's optimal default choice, as shown in Equation (14). As standard in the literature, we convexify the default decision to achieve convergence. In particular, we assume that in each period, the government's value function $V^d(y)$ is subject to an i.i.d. shock $\epsilon_V \sim \mathcal{N}(1,\sigma_v^2)$ so that the government defaults if $V^r(\cdot) < V^d(\cdot) \times \epsilon_v$. We choose $\sigma_v^2$ to be small enough ($\sigma_v^2 = 2.25 \times 10^{-6}$) so that the convexified solution does not significantly differ from the "true" solution of the model. Let $d(y,\tau,B)$ denote the optimal default choice.

5. Taking the policy functions $B'(y,\tau,B)$ and $d(y,\tau,B)$ as given, we update $q(y,\tau,B')$ according to Equation (17). We use cubic splines to evaluate the right-hand side of the pricing equation at $B'' \equiv B'(y',\tau',B')$.

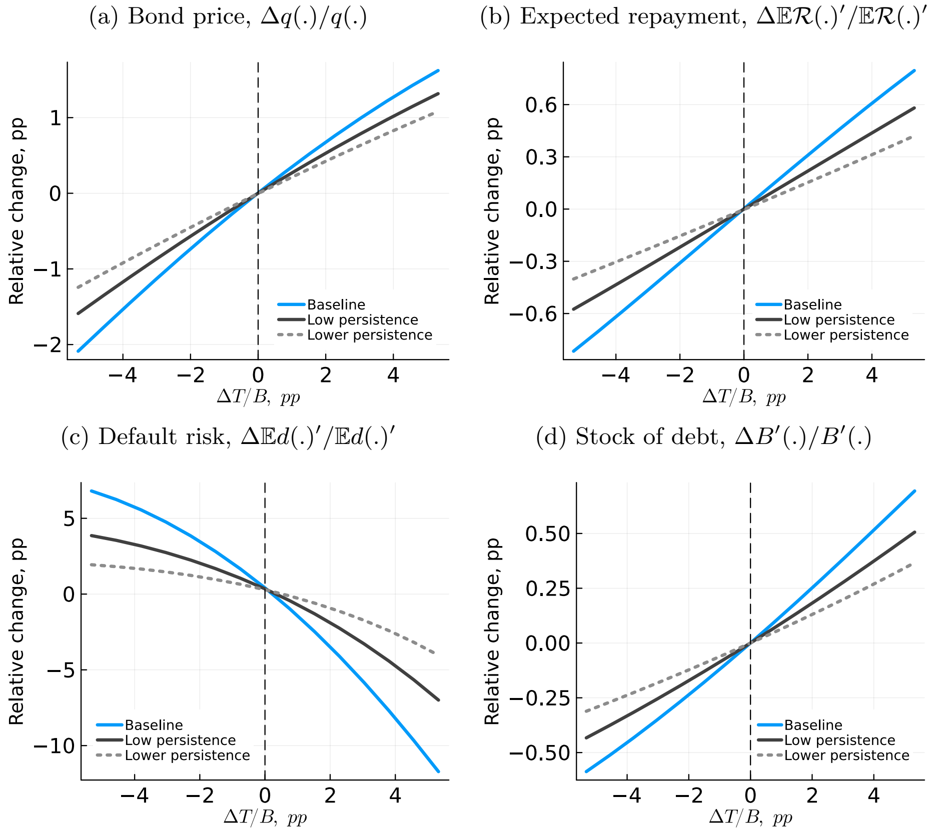
6. We iterate over the previous steps until convergence of the value functions and the bond price function.

### C.4 Understanding the Source of the Biases

What explains the difference between the reduced-form and structural elasticity? To address this question, we analyze the mechanisms behind changes in the expected repayment function as a results of a shift in $\tau$.

The first three panels of Figure C1 show the within-period effects resulting from shifts in the passive demand. To this end, we shock $\tau'$, and analyze the responses of bond prices, expected repayment, and default risk from the opening to the closing of the secondary market. The blue lines show the results under our baseline parameterization, while the solid and dotted gray lines indicate outcomes for scenarioes where the $\{\tau\}$ process is less persistent. Panels (a) and (b) show that there is a monotone relation between changes in the passive demand, bond prices, and expected repayment. For a 5% increase in the passive demand (as

Appendix Figure C1
Effects of Changes in demand on prices and policies




Note: The figure shows how changes in the passive demand (i.e., FIR) affect bond prices, expected repayment, default risk, and the bond supply. The blue lines show results under our baseline calibration. The gray lines show results for parameterizations in which we decrease the persistence of the FIR. For these cases, we set $\rho_\tau = 0.50$ and $\rho_\tau = 0.25$. In all cases, we evaluate these changes at the mean value for endowment and debt.

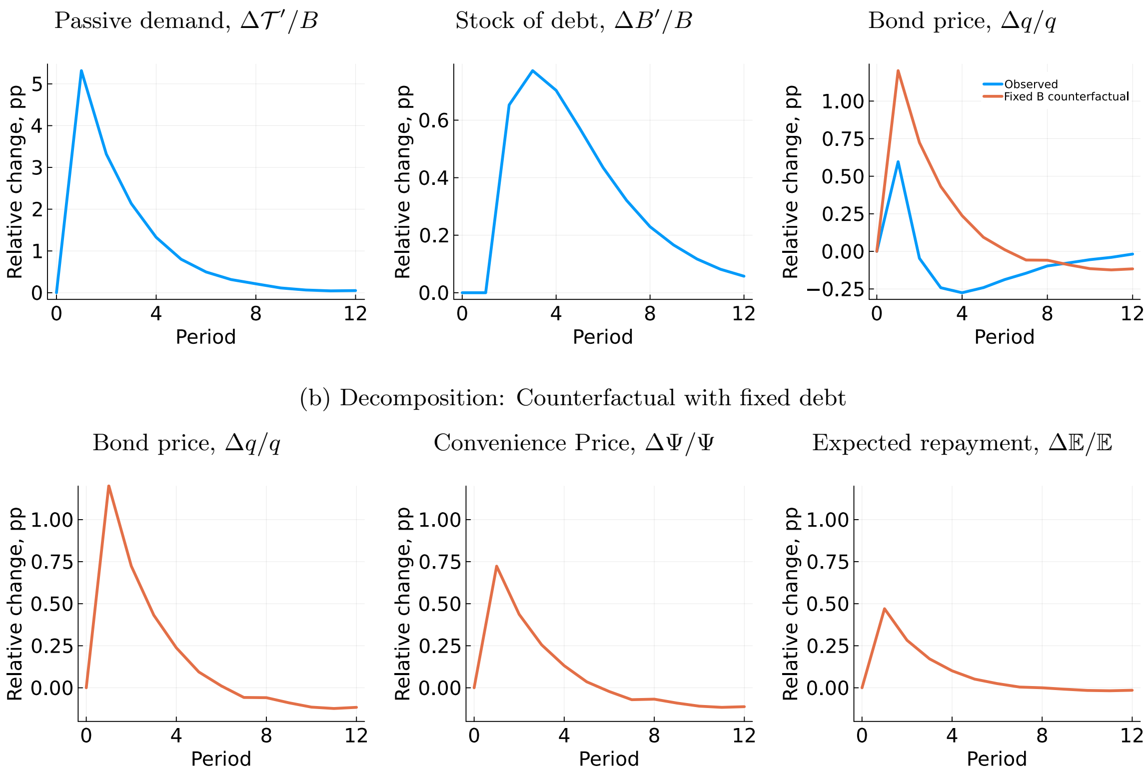
a share of the total stock of debt), bond prices increase by 1% and about half of that increase is explained by an increase in expected repayment. Panel (c) shows the change in one-period ahead default risk. For a 5% increase in the passive demand, default risk decreases more than 10%. Importantly, as the persistence of the $\tau$ process decreases, the implied changes on bond prices, expected repayment, and default risk decrease.

While the one-period ahead default risk decreases on impact, one cannot directly map that reaction into higher bond prices. This is because, lenders' anticipate that the government will increase its debt supply as a response to the passive demand shock. To see this, Panel (d) shows how the government's current choice of debt responds to the $\tau'$ shock. The government finds it optimal to adjust its stock of debt in response to a change in the passive demand. The response, however, is not one-to-one: for a 5% increase (decrease) in the passive demand (as a share of the stock of debt), the government raises (lowers) its debt by less than 1%.

To shed further light on the dynamics of bond prices and policies, Figure C2 shows the impulse response to an increase in the passive demand. The top panel depicts the responses

Appendix Figure C2
Impulse response to an increase in the passive demand

(a) Effects on debt and bond prices

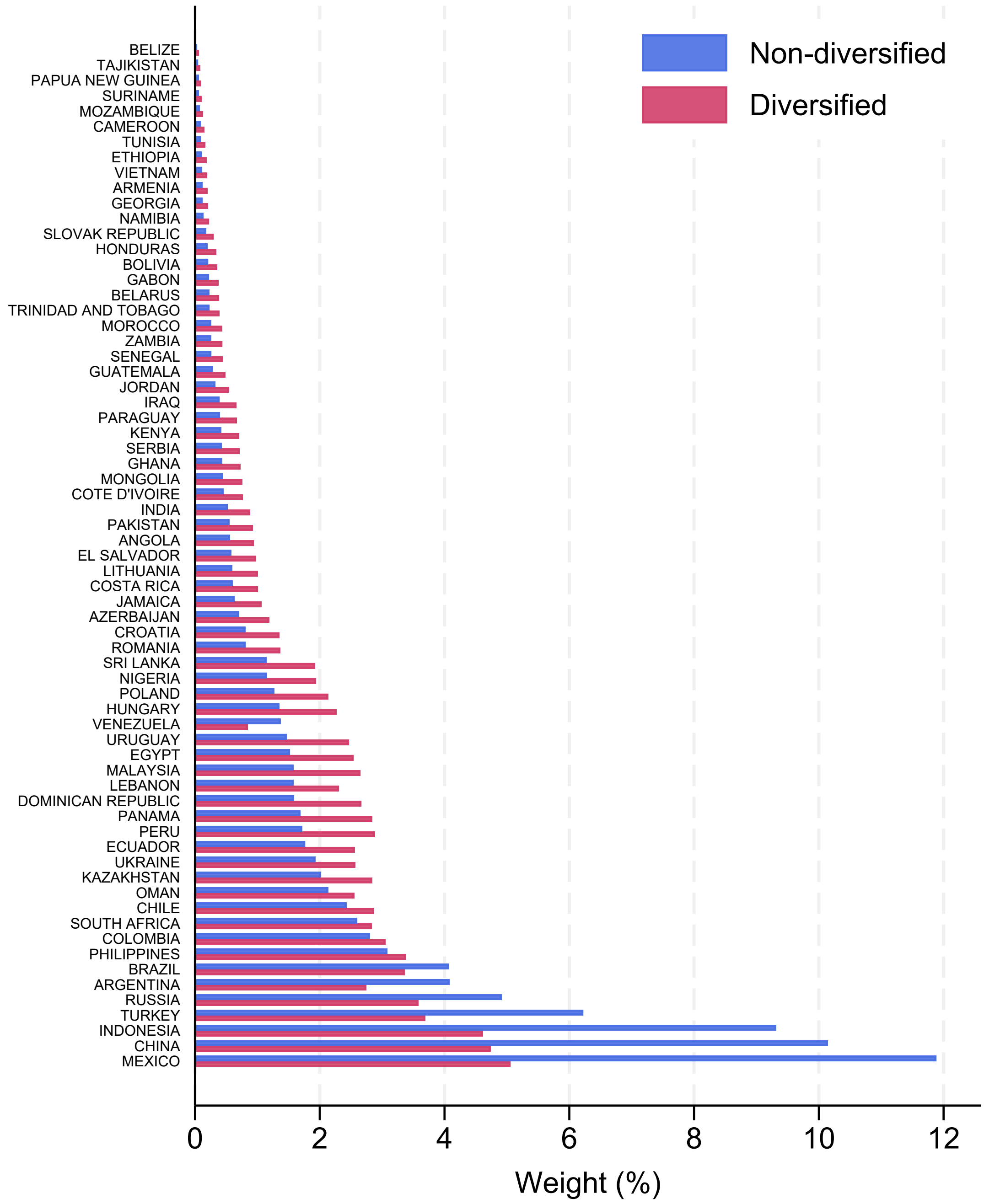



Note: The top panel shows impulse responses to an increase in the passive demand. The bottom panel shows a decomposition for bond price changes across time, in a counterfactual in which the stock of debt remains fixed.

of debt and bond prices. The government increases its debt upon the shock and the effects are quite persistent. Since the increase is not one-to-one with respect to the passive demand shock, bond prices increase as result of the larger demand —approximately 0.50%. The initial increase in bond prices is reversed after the first two quarters, as the passive demand shock fades, but the stock of debt (and thus default risk) remains higher. As a comparison, the orange line shows a counterfactual in which we keep the bond policy fixed. In this case, the bond price increases significantly more —about 1%. The bottom panel decomposes the change in bond prices under the counterfactual scenario in which debt is fixed. Since the passive demand shock is persistent, the convenience price term $\Psi(.)$ increases initially, and its effects gradually fade over time. The expected future trajectories of $\Psi(.)$, as well as $B'(.)$ and $d(.)$, influence current and future expected repayments, as shown in the right panel.

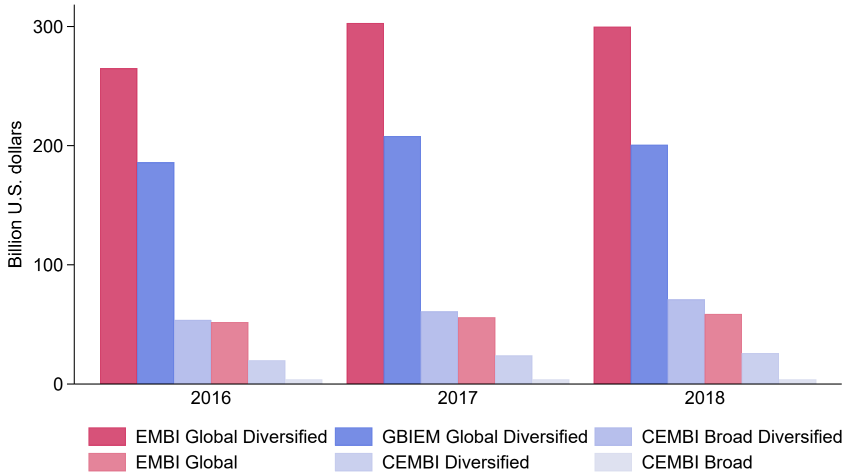
# D Additional Figures and Tables

Appendix Figure D1
EMBI Global country-level weights in December 2018



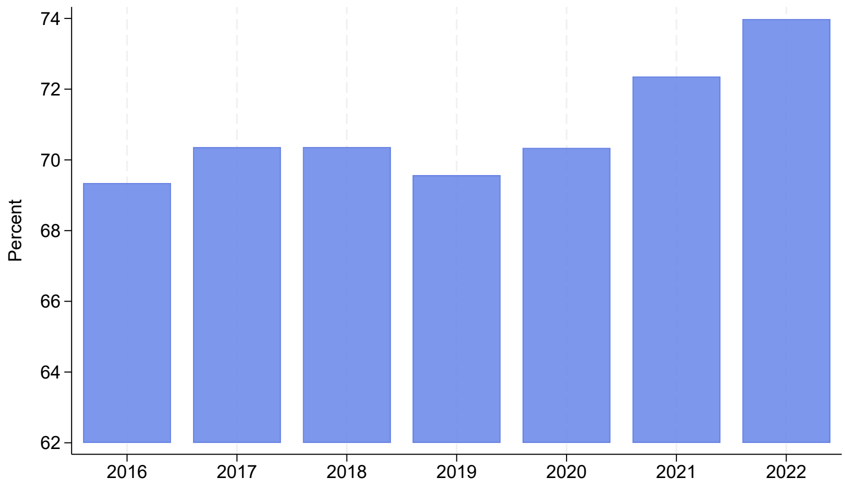

Note: The figure illustrates the EMBI Global country-level diversified and non-diversified weights for December 2018. Country-level weights are computed as the sum of the weights of all bonds from each country included in the index. Sources: J.P. Morgan Markets, and authors' calculations.

Appendix Figure D2
Assets under management benchmarked to emerging economies bond indexes



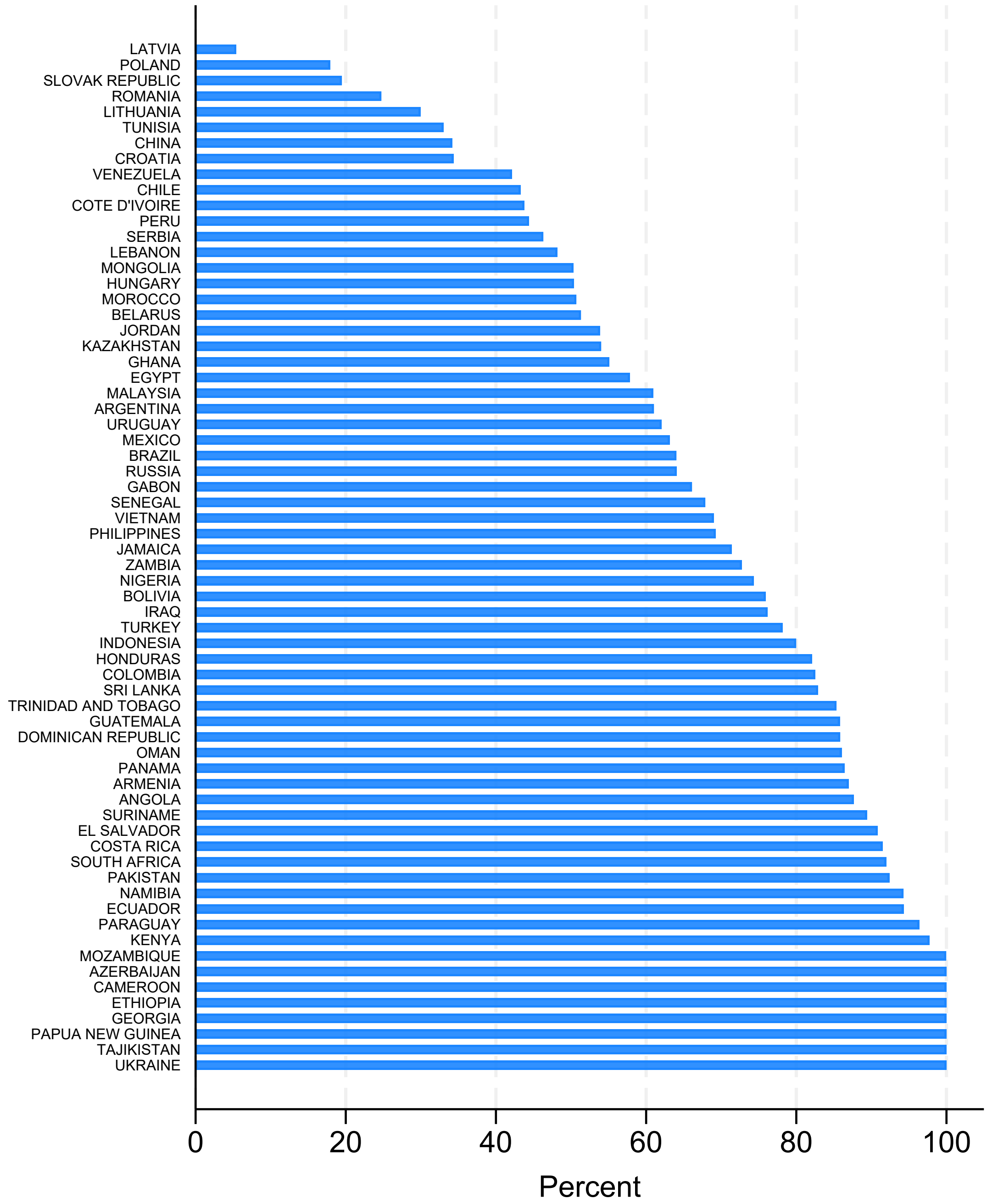

Note: The figure shows assets under management, in billions of U.S. dollars, benchmarked to emerging economies bond indexes. Sources: J.P. Morgan Markets, and authors' calculations.

Appendix Figure D3
Share of U.S. dollar-denominated emerging economies sovereign debt



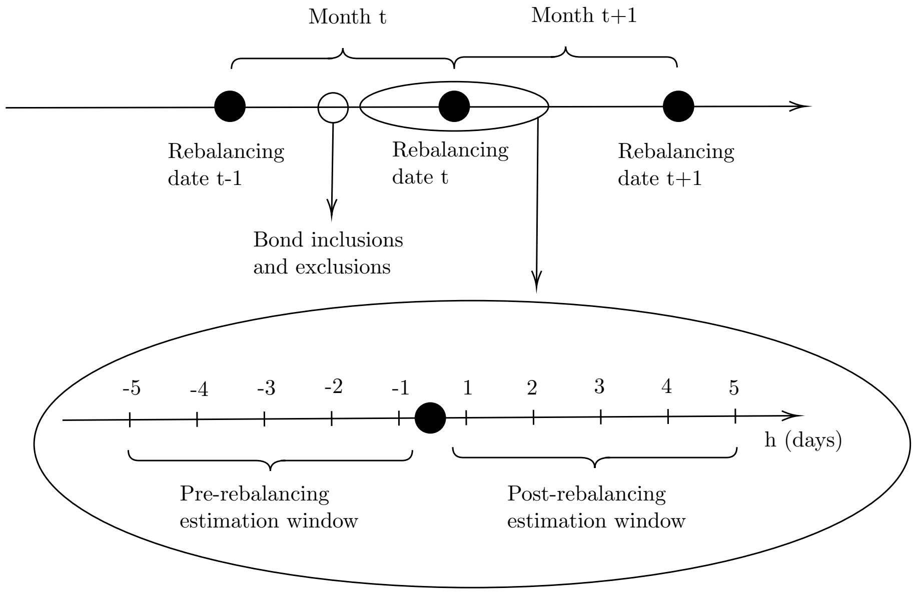

Note: The bars show the U.S. dollar-denominated sovereign debt in the EMBI Global index as a percentage of each country's general government debt securities issued in international markets. Averages are derived by calculating this percentage for each country and year, and then averaging these values annually across countries. Each country's percentage is weighted by its debt amount outstanding included in the EMBI Global indexes. Sources: BIS, J.P. Morgan Markets, and authors' calculations.

Appendix Figure D4
Share of U.S. dollar-denominated emerging economies sovereign debt

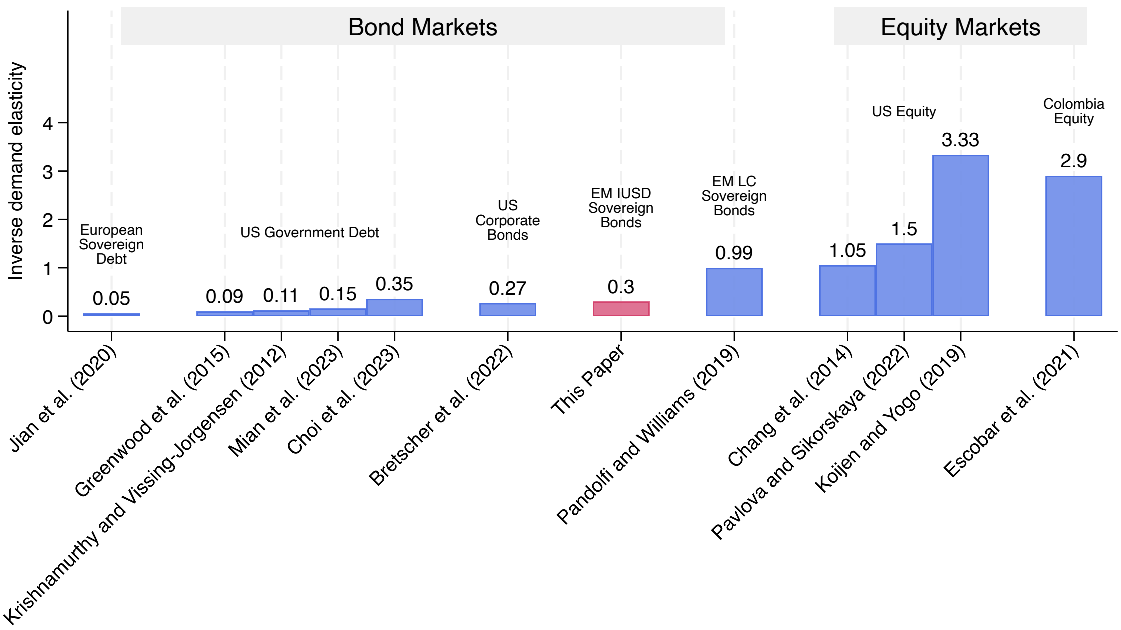



Note: The bars show the U.S. dollar-denominated sovereign debt in the EMBI Global index as a percentage of each country's general government debt securities issued in international markets. The averages are derived by calculating this percentage for each country and year, and then averaging these values across the years 2016–2022. Sources: BIS, J.P. Morgan Markets, and authors' calculations.

Appendix Figure D5
Timeline




Appendix Figure D6
Estimated inverse demand elasticities for financial markets




Note: EM IUSD Sovereign Bonds stands for emerging economies sovereign bonds issued internationally in U.S. dollars, while EM LC Sovereign Bonds stands for those issued in local currency. The elasticities in Jiang et al. (2021), Krishnamurthy and Vissing-Jorgensen (2012), and Greenwood et al. (2015) are taken from the review Table 2 of Mian et al. (2022) and are converted into an inverse demand price elasticity, assuming a duration of 7 for the average bond. For Choi et al. (2024), we take the midpoint elasticity from the IV estimates, while for our paper, we compute the midpoint in elasticity from Table 3. For the emerging economies local currency sovereign bonds, we take the estimated number in Table 15, Panel D of Pandolfi and Williams (2019) for GBI bonds, which we adjust by the share of AUM (23.6%) that behave de facto in a passive way. For that, we compute the asset share in EPFR tracking the GBI-EM Global Diversified with an $R^2$ exceeding that of ETFs tracking the same index. We determine the average $R^2$ for ETFs by using a weighted average (based on assets) of the $R^2$ of the ETFs.

Appendix Table D1
Log price and FIR: varying the share of passive funds

| Dependent Variable: Log Price | | | | | |
|---|---|---|---|---|---|
| | 25% | 30% | 35% | 40% | 45% |
| FIR X Post | 0.547 | 0.442 | 0.367 | 0.310 | 0.266 |
| | (0.190) | (0.188) | (0.156) | (0.132) | (0.114) |
| Bond-Month FE | Yes | Yes | Yes | Yes | Yes |
| Observations | 105,548 | 105,548 | 105,548 | 105,548 | 105,548 |
| N. of Bonds | 738 | 738 | 738 | 738 | 738 |
| N. of Countries | 68 | 68 | 68 | 68 | 68 |
| N. of Clusters | 1,576 | 1,576 | 1,576 | 1,576 | 1,576 |
| F (FS) | 419 | 1,862 | 1,813 | 1,764 | 1,715 |

Note: This table presents 2SLS estimates of log bond prices on the FIR measure (defined in Equation (2)), instrumented by $Z$ (defined in Equation (4)), around rebalancing dates. The first- and second-stage equations are described in Equation (6). The estimations use a symmetric five-trading-day window, with *Post* as an indicator variable (equal to 1 for the five trading days after rebalancing, and 0 otherwise). Each different column indicates the share of passive funds used to construct the FIR face amount measure. Month fixed effects are dummy variables equal to 1 for each rebalancing month, and 0 otherwise. Standard errors are clustered at the country-month level, and the sample period is 2016–2018.

Appendix Table D2
Log price and FIR: OLS estimates

| Dependent Variable: Log Price | | | | | | |
|---|---|---|---|---|---|---|
| | | [-5:+5] | | | No h=-1 | |
| Post | 0.000 | 0.001 | 0.000 | | 0.001 | |
| | (0.000) | (0.000) | (0.000) | | (0.000) | |
| FIR | 1.160 | | | | | |
| | (0.643) | | | | | |
| FIR X Post | 0.197 | 0.198 | 0.197 | 0.134 | 0.236 | 0.167 |
| | (0.076) | (0.077) | (0.076) | (0.086) | (0.076) | (0.092) |
| Bond FE | Yes | Yes | No | No | No | No |
| Month FE | Yes | No | No | No | No | No |
| Bond Characteristics-Month FE | No | Yes | No | No | No | No |
| Country-Month FE | No | Yes | No | No | No | No |
| Bond-Month FE | No | No | Yes | Yes | Yes | Yes |
| Month-Post FE | No | No | No | Yes | No | Yes |
| Bond Controls | No | Yes | No | No | No | No |
| Observations | 105,548 | 105,508 | 105,548 | 105,548 | 84,433 | 84,433 |
| N. of Bonds | 738 | 738 | 738 | 738 | 738 | 738 |
| N. of Countries | 68 | 68 | 68 | 68 | 68 | 68 |
| N. of Clusters | 1,576 | 1,575 | 1,576 | 1,576 | 1,576 | 1,576 |

Note: This table presents OLS estimates of log bond prices on the FIR measure (Equation (2)), around rebalancing dates. The estimations use a symmetric five-trading-day window, with *Post* as an indicator variable (equal to 1 for the five trading days after rebalancing, and 0 otherwise). Month fixed effects are dummy variables equal to 1 for each rebalancing month (0 otherwise), and bond characteristics are fixed effects that interact maturity and ratings fixed effects. Maturity fixed effects are constructed by dividing a bond's time to maturity into four different categories: short (less than 5 years), medium (5–10 years), long (10–20 years), and very long (20+ years). Ratings from each bond are from Moody's. Bond controls indicate whether the estimation includes the log face amount and log stripped spread of the bond. Standard errors are clustered at the country-month level, and the sample period is 2016–2018.

Appendix Table D3

Log price and FIR Constant Prices: OLS estimates

| Dependent Variable: Log Price | | | | | | |
|---|---|---|---|---|---|---|
| | | [-5:+5] | | | No h=-1 | |
| Post | 0.001 | 0.001 | 0.001 | | 0.001 | |
| | (0.000) | (0.000) | (0.000) | | (0.000) | |
| FIR | 1.112 | | | | | |
| | (0.644) | | | | | |
| FIR X Post | 0.230 | 0.232 | 0.231 | 0.142 | 0.266 | 0.177 |
| | (0.075) | (0.076) | (0.075) | (0.086) | (0.075) | (0.092) |
| Bond FE | Yes | Yes | No | No | No | No |
| Month FE | Yes | No | No | No | No | No |
| Bond Characteristics-Month FE | No | Yes | No | No | No | No |
| Country-Month FE | No | Yes | No | No | No | No |
| Bond-Month FE | No | No | Yes | Yes | Yes | Yes |
| Month-Post FE | No | No | No | Yes | No | Yes |
| Bond Controls | No | Yes | No | No | No | No |
| Observations | 105,548 | 105,508 | 105,548 | 105,548 | 84,433 | 84,433 |
| N. of Bonds | 738 | 738 | 738 | 738 | 738 | 738 |
| N. of Countries | 68 | 68 | 68 | 68 | 68 | 68 |
| N. of Clusters | 1,576 | 1,575 | 1,576 | 1,576 | 1,576 | 1,576 |

Note: This table presents OLS estimates of log bond prices on a variation of the FIR measure from Equation (2), around rebalancing dates. This alternative measure holds prices constant when computing benchmark weights using the previous rebalancing period prices. The estimations use a symmetric five-trading-day window, with *Post* as an indicator variable (equal to 1 for the five trading days after rebalancing, and 0 otherwise). Month fixed effects are dummy variables equal to 1 for each rebalancing month (0 otherwise), and bond characteristics are fixed effects that interact maturity and ratings fixed effects. Maturity fixed effects are constructed by dividing a bond's time to maturity into four different categories: short (less than 5 years), medium (5–10 years), long (10–20 years), and very long (20+ years). Ratings from each bond are from Moody's. Bond controls indicate whether the estimation includes the log face amount and log stripped spread of the bond. Standard errors are clustered at the country-month level, and the sample period is 2016–2018.

Appendix Table D4
Log price and FIR: different windows

| Panel A-Dependent Variable: Log Price | | | | |
|---|---|---|---|---|
| | [-2:+2] | [-3:+3] | [-4:+4] | [-5:+5] |
| FIR X Post | 0.146 | 0.197 | 0.221 | 0.231 |
| | (0.053) | (0.071) | (0.086) | (0.099) |
| Bond-Month FE | Yes | Yes | Yes | Yes |
| Observations | 42,217 | 63,327 | 84,435 | 105,548 |
| N. of Bonds | 738 | 738 | 738 | 738 |
| N. of Countries | 68 | 68 | 68 | 68 |
| N. of Clusters | 1,576 | 1,576 | 1,576 | 1,576 |
| F (FS) | 1,660 | 1,662 | 1,664 | 1,666 |

| Panel B-Dep. Variable: Log Price (Excl. h=-1) | | | | |
|---|---|---|---|---|
| | [-2:+1] | [-3:+2] | [-4:+3] | [-5:+4] |
| FIR X Post | 0.220 | 0.257 | 0.271 | 0.263 |
| | (0.056) | (0.074) | (0.087) | (0.098) |
| Bond-Month FE | Yes | Yes | Yes | Yes |
| Observations | 21,106 | 42,216 | 63,325 | 84,433 |
| N. of Bonds | 738 | 738 | 738 | 738 |
| N. of Countries | 68 | 68 | 68 | 68 |
| N. of Clusters | 1,576 | 1,576 | 1,576 | 1,576 |
| F (FS) | 1,667 | 1,667 | 1,669 | 1,670 |

Note: This table presents 2SLS estimates of bond log prices on the FIR measure, with each column reporting estimates for different $h$-day symmetric windows before and after a rebalancing event. The sample period, the construction of $h-$day windows, and the 2SLS procedure are identical to those described in Table 3. Standard errors are clustered at the country-month level.

Appendix Table D5
Log price and FIR: dropping quasi-sovereign bonds

| Dependent Variable: Log Price | | | | |
|---|---|---|---|---|
| FIR | 1.078 | | | |
| | (0.924) | | | |
| FIR X Post | 0.249 | 0.249 | 0.249 | 0.175 |
| | (0.107) | (0.108) | (0.107) | (0.103) |
| Post | 0.000 | 0.000 | 0.000 | |
| | (0.000) | (0.000) | (0.000) | |
| Bond FE | Yes | Yes | No | No |
| Month FE | Yes | No | No | No |
| Bond Characteristics-Month FE | No | Yes | No | No |
| Country-Month FE | No | Yes | No | No |
| Bond-Month FE | No | No | Yes | Yes |
| Month-Post FE | No | No | No | Yes |
| Bond Controls | No | Yes | No | No |
| Observations | 73,140 | 73,100 | 73,140 | 73,140 |
| N. of Bonds | 430 | 430 | 430 | 430 |
| N. of Countries | 65 | 65 | 65 | 65 |
| N. of Clusters | 1,513 | 1,512 | 1,513 | 1,513 |
| F (FS) | 0 | 3,151 | 3,231 | 1,099 |

Note: This table presents 2SLS estimates of log bond prices on the FIR measure (Equation (2)), instrumented by $Z$ (Equation (4)), around rebalancing dates. The first- and second-stage equations are described in Equation (6). The estimations use a symmetric five-trading-day window, with *Post* as an indicator variable (equal to 1 for the five trading days after rebalancing, and 0 otherwise). Month fixed effects are dummy variables equal to 1 for each rebalancing month (0 otherwise), and bond characteristics are fixed effects that interact maturity and ratings fixed effects. Maturity fixed effects are constructed by dividing a bond's time to maturity into four different categories: short (less than 5 years), medium (5–10 years), long (10–20 years), and very long (20+ years). Ratings from each bond are from Moody's. Bond controls indicate whether the estimation includes the log face amount and log stripped spread of the bond. Standard errors are clustered at the country-month level, and the sample period is 2016–2018.

Appendix Table D6
Log price and FIR: spread heterogeneity (3 groups)

| Dependent Variable: Log Price | | | | | | |
|---|---|---|---|---|---|---|
| | High Spread | | Median Spread | | Low Spread | |
| FIR | 2.179 | | 0.140 | | 0.391 | |
| | (1.810) | | (0.508) | | (0.361) | |
| FIR X Post | 0.380 | 0.381 | 0.325 | 0.322 | 0.087 | 0.087 |
| | (0.166) | (0.165) | (0.152) | (0.151) | (0.098) | (0.098) |
| Post | 0.001 | 0.001 | 0.001 | 0.001 | -0.000 | -0.000 |
| | (0.001) | (0.001) | (0.000) | (0.000) | (0.000) | (0.000) |
| Bond FE | Yes | No | Yes | No | Yes | No |
| Month FE | Yes | No | Yes | No | Yes | No |
| Bond-Month FE | No | Yes | No | Yes | No | Yes |
| Observations | 28,105 | 28,104 | 28,055 | 28,053 | 28,276 | 28,276 |
| N. of Bonds | 381 | 381 | 453 | 453 | 375 | 375 |
| N. of Countries | 58 | 58 | 51 | 51 | 43 | 43 |
| N. of Clusters | 975 | 975 | 837 | 837 | 634 | 634 |
| F (FS) | 501 | 2,342 | 436 | 720 | 0 | 882 |

Note: This table presents 2SLS estimates of log bond prices on the FIR measure (Equation (2)), instrumented by $Z$ (Equation (4)), around rebalancing dates. The first- and second-stage equations are described in Equation (6). The estimations use a symmetric four-trading-day window excluding $h = -1$ and $h = +5$, with *Post* as an indicator variable (equal to 1 for the five trading days after rebalancing, and 0 otherwise). The sample is divided into bonds with high spreads (Columns 1 and 2), median spreads (Columns 3 and 4), and low spread (Columns 5 and 6), with spreads divided according to their 33.3 and 66.6 percentile into the three different buckets. Month fixed effects are dummy variables equal to 1 for each rebalancing month, and 0 otherwise. Standard errors are clustered at the country-month level, and the sample period is 2016–2018.