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Growth-Indexed Bonds and Debt Distribution: Too Little, Too Costly?

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ABSTRACT: Sovereign state-contingent bonds have rarely been issued despite their theoretical debt-stabilization properties. This paper revisits this puzzle by analyzing when growth-indexed bonds are too limited in scale, and when they are too costly, to materially improve debt sustainability. The results show that the benefits of indexation are highly heterogeneous across countries. Under the realistic assumption that 20 percent of the debt stock is indexed, reductions in the upper tail of the debt distribution are modest. Full indexation yields more substantial improvements, especially when combined with an optimal loading on growth. Yet a sustained premium of 100 basis points would still offset most of the gains for many countries. These findings suggest that the debt-stabilization properties of growth-indexed bonds would be limited, unless a large-scale and coordinated effort achieves both broad adoption and low issuance premia.

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WORKING PAPERS

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1 Introduction

Advanced economies have experienced large increases in their public debt-to-GDP ratios over the past 15 years, driven in particular by the global financial crisis (GFC) and the COVID-19 shock. The deep recession and slow economic recovery which followed the GFC raised concerns about debt sustainability in some countries, creating a vicious cycle: Negative shocks on output and on public finances reduced debt sustainability, which translated into higher borrowing costs, thus worsening debt sustainability in those countries even more. To contain the impact of increasing borrowing costs, governments went through fiscal consolidation, which acted as a drag on economic activity. These dynamics were particularly salient in countries such as Spain and France, where the debt-to-GDP ratio rose, respectively, from 35 to 100 percent and from 64 to 92 percent between 2007 and 2013 (Figure 1).

Although current debt levels may seem sustainable under baseline projections, negative shocks to growth or interest rates could put debt ratios on an unsustainable path. Against this background, the issuance by sovereigns of debt instruments indexed to output—an idea introduced in its modern form by Shiller (1998) and further developed by Borensztein and Mauro (2004)—has attracted renewed policy interest (Shiller et al., 2018). While sovereigns traditionally issue debt at fixed interest rates, growth-indexed bonds (GIBs) pay a time-varying coupon determined by a specific indexation formula. In its simplest form, the nominal indexed coupon rate at time t, denoted $\bar{i}_t$, is equal to the nominal growth rate g_t plus a predetermined contract term k_t:

$$\bar{i}_t = g_t + k_t \tag{1}$$

where k_t is known at $t-1$ and ensures that an investor is indifferent between holding a GIB and a conventional plain-vanilla bond.[1]

[1]This paper follows Blanchard et al. (2016) by focusing on a simple continuous symmetric formula, which allows for analytically tractable results and provides more complete risk sharing to the sovereign than the threshold specification in Borensztein and Mauro (2004) and Chamon and Mauro (2006). The impact of a

The theoretical case for GIBs operates through two channels. First, by indexing coupon payments to growth, GIBs reduce the variability of the debt-to-GDP ratio and, therefore, the likelihood of reaching dangerously high debt levels (Barr et al., 2014, Benford et al., 2016, Blanchard et al., 2016, Kim and Ostry, 2021, Pienkowski, 2017). Second, by making interest payments procyclical, GIBs allow for more counter-cyclical fiscal policy during recessions, avoiding self-defeating consolidations (Borensztein and Mauro, 2004, Demertzis and Zenios, 2019, Hatchondo and Martinez, 2012). Yet, if domestic residents hold such indexed bonds, their interest revenue will increase during good times and decrease during bad times. This procyclicality in their income may reinforce, rather than smooth, the economic cycle.

Notwithstanding their theoretical appeal, GIBs have rarely been issued in practice. Past issuance has been limited in size and confined to debt-restructuring episodes (Costa Rica, Bulgaria, and Bosnia-Herzegovina in the 1980s and 1990s; Argentina in 2005, Greece in 2012, and Ukraine in 2015), and no sovereign has issued GDP-linked bonds with full symmetric risk-sharing on a broad scale.[2] Two concerns feature prominently in the debate. First, moral hazard and data credibility: manipulation of official statistics is a legitimate worry, though it is less acute in economies with independent statistical institutions. Second, pricing: novelty, liquidity, and ambiguity premia may make GIBs expensive relative to conventional bonds (Igan et al., 2021, Roch and Roldán, 2023). Barr et al. (2014) note two opposing effects on funding costs: higher risk premia shift the right tail of the debt distribution upward, while lower debt-ratio uncertainty compresses it. Consiglio and Zenios (2018) price GIBs in incomplete markets and find that a premium of approximately 100 basis points—the benchmark used in Section 5—is plausible, a conclusion corroborated by the no-arbitrage pricing approach of Eguren Martin et al. (2021).

nominal coupon floor on the debt distribution is discussed in Section 4.

[2]See Pina (2022) for a comprehensive list of issued indexed bonds.

In a related paper, Mouabbi et al. (2024) study the debt-stabilizing properties of GDP-linked bonds using a consumption-based macro-finance model with time-varying risk premia and long-term bond issuance, finding that GDP-linked securities do not imply more beneficial debt-to-GDP ratios in the long run. The present paper complements their approach and contributes to the literature in three ways. First, it develops a reduced-form framework based on a standard debt accumulation process yielding closed-form expressions for the conditional variance of the debt ratio. This allows us to derive and compute optimal growth indexation coefficients across countries. The findings suggest that for most governments the optimal coefficient which minimizes the conditional variance of the debt ratio is greater than one. Second, the analysis covers a wide range of advanced and emerging economies, enabling cross-country comparisons of the gains from indexation under different assumptions regarding the share of indexed debt and the indexation coefficient. Third, the paper quantifies country-specific maximum net premia that would offset the variance-reduction benefit of GIBs at different horizons. Despite their different methodologies, both studies conclude that the debt-stabilization benefits of GIBs might remain limited and are highly sensitive to scale and cost.

The main findings can be summarized as follows. First, the reduction in debt-ratio variance is highly heterogeneous. For the average country in our sample, full indexation reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 91st percentile of the non-indexed distribution—equivalent to reducing a 9 percent tail probability to 1 percent. This distinction is economically meaningful, and for a few countries this stabilizes the upper tail of the debt-distribution (Figure 2). The results are particularly salient for countries with a less volatile primary balance-to-GDP ratio: In Mexico and Japan, full indexation reduces a tail probability of more than 20 percent to 1 percent (Table 2). Full indexation also significantly reduces the 75th-percentile tail in these countries, which may be more relevant for policymakers.

Second, the framework emphasizes that over-indexation can further lower the conditional variance of the debt-to-GDP ratio. For the average country in our sample, full debt indexation with an optimal growth indexation coefficient reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 87th percentile of the non-indexed distribution. In Spain and Costa Rica, where the primary balance is strongly correlated with growth (Table 4), full indexation with an optimal coefficient achieves important debt-stabilization benefits, reducing a 30 percent tail probability to 1 percent (Table 5).

Lastly, scale and pricing are critical. Indexing only 20 percent of the debt stock provides very modest reductions in the 99th-percentile tail for any country in the sample (Table 2). Moreover, a sustained net premium of 100 basis points would increase the upper tail of the debt distribution for most countries, eliminating the benefits of reduced variance (Table 6). As such, under reasonable assumptions, the benefits from growth-indexed bonds in terms of debt stabilization are much lower than traditionally assumed. The difficulties to issue a large share of indexed bonds, combined with an implicit high premium required by investors, provide an explanation for the apparent non-contingency puzzle.[3] This implies, consistent with the findings from Demertzis and Zenios (2019), that only a large-scale and preferably coordinated issuance at low premia could generate meaningful debt-stabilization gains.

The remainder of the paper is organized as follows. Section 2 derives the conditional variance of the debt-to-GDP ratio under GIB issuance and characterizes the optimal shared of indexed debt. Section 3 derives additional variance reductions under alternative indexation formulas and derives an optimal growth indexation coefficient. Section 4 provides Monte Carlo estimates of tail-risk reductions and multiple robustness checks. Section 5 introduces risk-averse investors and quantifies the maximum acceptable premium. Section 6 concludes.

[3]The term 'non-contingency puzzle' was coined by Levy (2016).

2 Simple GIBs and Debt Distribution

Public debt is considered sustainable if the debt-to-GDP ratio is likely to follow a stable or declining path over the relevant horizon. Sovereigns and investors are particularly concerned with the upper tail of the debt-to-GDP distribution.[4] Growth-indexed bonds (GIBs) can reduce this tail risk by lowering the conditional variance of the debt ratio, but only at the potential cost of a higher expected debt level if risk-averse investors require a premium. This section derives the variance reduction under simple GIBs, assuming risk-neutral investors, costless contracts, and a known variance-covariance matrix of the growth rate g_t, the effective interest rate i_t, and the primary balance-to-GDP ratio pb_t.

2.1 Debt Dynamics with Plain-Vanilla Bonds

The government's nominal debt D_t satisfies:

$$D_t = (1 + i_t)D_{t-1} - PB_t, \tag{2}$$

where PB_t is the nominal primary surplus. Using the standard first-order approximation for small i_t and g_t, the debt dynamics equation is:

$$\Delta d_t = (i_t - g_t)\, d_{t-1} - pb_t. \tag{3}$$

[4] In general terms, public debt can be regarded as sustainable when the primary balance needed to at least stabilize debt under both the baseline and realistic shock scenarios is economically and politically feasible, such that the level of debt is consistent with an acceptably low rollover risk and with preserving potential growth at a satisfactory level. International Monetary Fund (2021)

Conditioning on the information set $\mathcal{F}_{t-1}$, the one-period-ahead conditional variance of the change in the debt ratio is:

$$\mathrm{Var}_{t-1}(\Delta d_t) = \mathrm{Var}_{t-1}(pb_t) + d_{t-1}^2\,\mathrm{Var}_{t-1}(i_t - g_t) - 2\,d_{t-1}\,\mathrm{Cov}_{t-1}(pb_t,\, i_t - g_t)\,. \tag{4}$$

The higher the variance of the primary balance and the interest-growth differential, and the more negative the correlation between the primary balance and the interest-growth differential, the higher the uncertainty in the future public debt ratio.

2.2 Debt Dynamics with Simple GIBs

Suppose that a share X of the outstanding debt stock is indexed to growth. The indexed coupon is as in equation (1), with $k_t = i_t - \mathbb{E}_{t-1}[g_t] \in \mathcal{F}_{t-1}$.[5] The interest rate i_t is determined at date $t-1$, therefore k_t is known at $t-1$ and enters the debt dynamics as a pre-determined constant within period t:

$$\bar{i}_t = g_t + \underbrace{i_t - \mathbb{E}_{t-1}[g_t]}_{\equiv\; k_t}\,. \tag{5}$$

Note that k_t differs from a default, risk, liquidity, or novelty premium; any such wedge would enter separately. The debt dynamics equation becomes:

$$\Delta d_t = \big[X k_t + (1-X)(i_t - g_t)\big] d_{t-1} - pb_t, \tag{6}$$

[5] Another widely discussed design indexes the bond's principal rather than its coupon to GDP (Shiller, 1998). Coupon-indexed bonds are preferable from a market liquidity standpoint: they provide more immediate fiscal relief—potentially through a negative coupon—during recessions, and make it easier to analyze alternative indexation formulas. Consiglio and Zenios (2018) further show that principal-indexed bonds carry a higher premium, and Williamson (2017) provides a comprehensive comparison.

and, the conditional variance of Δd_t is:

$$\mathrm{Var}_{t-1}(\Delta d_t) = \mathrm{Var}_{t-1}(pb_t) + (1-X)^2\, d_{t-1}^2\, \mathrm{Var}_{t-1}(i_t - g_t) - 2(1-X)\, d_{t-1}\, \mathrm{Cov}_{t-1}(pb_t,\, i_t - g_t)\,. \tag{7}$$

When $X = 1$ the sovereign is fully hedged against growth shocks and the conditional variance of the debt-to-GDP ratio simply collapses to the one of the primary balance-to-GDP ratio:

$$\mathrm{Var}_{t-1}(\Delta d_t) = \mathrm{Var}_{t-1}(pb_t)\,. \tag{8}$$

2.3 Reducing the Uncertainty Around the Debt Ratio

Since k_t is defined to make a risk-neutral investor indifferent between GIBs and conventional bonds, the conditional mean of Δd_t is not affected by the indexed share X. Equations (4) and (7) imply that GIB issuance reduces the conditional variance if and only if

$$X < 2 - \frac{2\,\mathrm{Cov}_{t-1}(pb_t,\, i_t - g_t)}{d_{t-1}\,\mathrm{Var}_{t-1}(i_t - g_t)}. \tag{9}$$

Converting the entire debt stock into GIBs reduces the conditional debt-ratio uncertainty whenever $\mathrm{Cov}_{t-1}(pb_t,\, i_t - g_t) < 0$—i.e., whenever the primary balance and the interest-growth differential move in opposite directions. Using the IMF April 2023 WEO database, we find that this sufficient condition is satisfied for 25 of the 31 countries in the sample over 1996–2021 (Table 1), driven primarily by the positive co-movement between growth and the primary balance.

The variance-minimizing indexed share is:

$$X^{\star}_{t-1} = 1 - \frac{\mathrm{Cov}_{t-1}(pb_t,\, i_t - g_t)}{d_{t-1}\,\mathrm{Var}_{t-1}(i_t - g_t)}. \tag{10}$$

When $\text{Cov}_{t-1}(pb_t,\, i_t - g_t) < 0$—the empirically dominant case—we have $X^{\star}_{t-1} > 1$. This "over-indexation" further reduces debt variance by lowering coupon payments precisely when the primary balance is also depressed.

This result highlights the fact that despite its simple design, the indexation formula in equations (1) and (5) does not provide direct insurance against fluctuations in the primary balance, which are often quantitatively important. In principle, it is possible for the sovereign to reduce the variance of its debt ratio distribution to a level lower than the variance of its primary balance. Section 3 explores richer formulas that address this limitation.

3 Alternative Indexation Formulas

This section derives extensions of the simple growth-indexed bond that can further reduce the uncertainty around the debt ratio.

3.1 A Theoretical Benchmark: The Fully Contingent Formula

The indexation formula that would eliminate all one-period ahead conditional uncertainty about the debt ratio is:

$$\bar{i}_t = \frac{pb_t}{d_{t-1}} + g_t + k_t. \tag{11}$$

This formula, which indexes the coupon to growth, the primary balance, and the lagged debt ratio, is not implementable in itself as it is not acceptable to investors: a sovereign would have strong incentives to manipulate the primary balance to reduce interest payments, creating a moral hazard problem. Nevertheless, it is a useful theoretical benchmark: the minimum achievable conditional debt variance is zero, and the formulas below can be understood as progressively better approximations to this frontier.

3.2 Growth-indexed Bonds with an Optimal Coefficient

In the more general formulation of growth-indexed bonds, the indexed coupon is:

$$\bar{i}_t = c\, g_t + k_t, \tag{12}$$

where $c \geq 0$ is the growth-indexation coefficient. In the simplest case analyzed above $c = 1$, but in theory this coefficient could take any positive value. The debt dynamics become:

$$\Delta d_t = \big[X k_t + (1 - X) i_t - (1 - cX) g_t\big] d_{t-1} - pb_t. \tag{13}$$

The variance-minimizing coefficient for a given X is:

$$c^{\star}_{t-1} = \frac{1}{X}\left[1 + \frac{\mathrm{Cov}_{t-1}(g_t,\, pb_t)}{d_{t-1}\,\mathrm{Var}_{t-1}(g_t)} - \frac{(1 - X)\,\mathrm{Cov}_{t-1}(i_t,\, g_t)}{\mathrm{Var}_{t-1}(g_t)}\right]. \tag{14}$$

When the entire debt stock is indexed, $X = 1$, this simplifies to:

$$c^{\star}_{t-1} = 1 + \frac{\mathrm{Cov}_{t-1}(g_t,\, pb_t)}{d_{t-1}\,\mathrm{Var}_{t-1}(g_t)}, \tag{15}$$

and the resulting conditional variance is:

$$\mathrm{Var}_{t-1}(\Delta d_t) = \mathrm{Var}_{t-1}(pb_t)\big(1 - \rho^2_{g,pb,t-1}\big)\,, \tag{16}$$

where $\rho_{g,pb}$ is the conditional correlation between growth and the primary balance. Equation (16) has a clean interpretation: the efficiency of growth indexation using this optimal coefficient entirely depends on how well the growth rate proxies the primary balance. When $\rho_{g,pb} = 0$, there is no additional gain beyond simple indexation ($c^{\star} = 1$); when $\rho_{g,pb} = 1$, the variance collapses to zero, recovering the fully contingent case. This gives a simple character-

ization of the optimal indexation: $c^\star$ is the coefficient that makes debt changes uncorrelated with the growth rate (Blanchard, 1979).

Additional remark. Throughout the paper, the object minimized is the conditional one-period-ahead variance $\text{Var}_{t-1}(\Delta d_t)$ described in equation (7). This allows us to keep the analysis tractable and derive an optimal closed-form indexation formula despite the non-linear nature of the debt accumulation process. As a result, the optimal indexed share and growth loading derived above are state-dependent. The conditions under which the one-period conditional rule also minimizes variance at longer horizons are derived in Appendix A.1 (Proposition 1).

3.3 Growth-Gap Indexed Bonds

For a sub-sample of 15 advanced economies with available output gap data, a further extension indexes the coupon to both the growth rate and the output gap:

$$\bar{i}_t = a\, g_t + b\, z_t + k_t, \tag{17}$$

where z_t is the output gap. The optimal coefficients $(a^\star, b^\star)$ and the additional variance reduction are derived in Appendix A.2. Including the output gap can further reduce debt variance when the gap has independent explanatory power for the primary balance, but the marginal gains are often small in practice, and the additional complexity due to uncertainties in estimating the output gap itself would likely generate a higher issuance premium.

In addition to growth and the output gap, fiscal variables may respond to changes in asset prices, real estate prices, interest rates, exchange rates, commodity prices, and other variables. The alternative indexation formulas could take various forms, ideally reflecting the sovereign's capacity to serve its debt, but this paper keeps them relatively simple and

restricts the analysis to the growth rate only and to its combination with the output gap in Appendix A.2. The main reasoning would be the same if using any other variable.

4 Simulations

4.1 Methodology and Data

To quantify the gains—defined as reductions in the upper tail of the debt-to-GDP ratio distribution—from each indexation formula, we extend the fan-chart methodology of Blanchard et al. (2016) to a cross-country setting. The analysis covers 31 advanced and emerging economies.[6] Annual data are drawn from the April 2023 IMF World Economic Outlook (WEO) database, covering 1996–2021. The variables used are the nominal GDP growth rate, the effective nominal interest rate on debt (constructed as net interest payments divided by lagged debt), and the primary balance as a share of GDP.

Baseline expected values for interest rates, growth, and the primary balance are set equal to the April 2023 IMF WEO projections for each year through 2028, and held constant at the 2028 level thereafter. Shocks are drawn from a multivariate normal distribution with covariance matrix estimated over 1996–2021. The benchmark analysis assumes shocks are independently and identically distributed (i.i.d.) across time. All results are based on 10,000 Monte Carlo draws over 10-year and 20-year horizons.

In the Monte Carlo simulations, k_t is implemented as pre-determined but time-varying: at each forecast date t, $k_t = \hat{i}_t - \hat{g}_t$, where $\hat{i}_t$ and $\hat{g}_t$ are the IMF WEO baseline forecasts for the nominal interest rate and nominal growth rate, respectively. This choice ensures that the expected indexed coupon equals the expected nominal coupon in each period when

[6]The countries are Argentina, Australia, Austria, Belgium, Brazil, Cameroon, Canada, Chile, Colombia, Costa Rica, Egypt, France, Germany, Greece, India, Indonesia, Israel, Italy, Japan, Korea, Malta, Mexico, Netherlands, Peru, Portugal, South Africa, Spain, Sweden, Türkiye, United Kingdom, and the United States.

studying simple nominal GIBs, so that expected debt trajectories are comparable to a first-order approximation under indexation and non-indexation, given that shocks are normally distributed and i.i.d., and absent any premium.[7] For values beyond 2028, we assume that k_t remains constant at its 2027 value over time. The implied k_t values for 2022–2029 are reported in Table A.1 (Appendix). The simulations treat these values as predetermined, consistent with the framework developed in Sections 2 and 3.

4.2 Simple Nominal Growth-indexed Bonds

Table 1 shows that the interest-growth differential and the primary balance are negatively correlated for most countries, confirming that simple GIBs would reduce debt-ratio variance for most of the sample. The impact of simple indexation (equation 5) is assessed in two steps. First, Figure 2 shows fan charts for the 1st, 50th, and 99th percentiles of the debt/GDP distribution under full (100%) and partial (20%) indexation for selected countries. Second, Table 2 quantifies the tail-risk reduction by reporting, for each country, the percentile of the non-indexed distribution that coincides with the 99th or 75th percentile of the indexed distribution after 10 years.

The results are heterogeneous. For the average country in our sample, full indexation reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 91st percentile of the non-indexed distribution—equivalent to reducing a 9 percent tail probability to 1 percent. This distinction is economically meaningful, with such a shift comparable to the boundary between non-investment and investment-grade sovereign debt, and for a few countries this leads to a stabilization of the upper tail of the debt-distribution (Figure 2). The results are particularly striking for countries with a less volatile primary balance ratio: In Mexico and Japan, full indexation reduces a tail probability of more than 20 percent to 1 percent (Table 2). Full indexation also significantly reduces the 75th-percentile

[7] We confirmed that this is empirically true for all countries in all specifications.

tail in these countries, which may be more relevant for policymakers.[8] For Cameroon, by contrast, the reduction is negligible (a drop from the 99th to the 98th percentile).

However, despite these encouraging results for a handful of countries, the effect of partial indexation is extremely limited overall. For all 31 countries in the sample, indexing 20 percent of the debt stock reduces the 99th-percentile tail by at most 2 percentile points—essentially negligible from a policy standpoint (Table 2). This is a crucial finding: the share of debt indexed to growth is a first-order consideration, and the typical issuance share that sovereigns might achieve in practice generates little to no insurance.

4.3 Growth-indexed Bonds with Optimal Coefficient

Using the general formula (12) with $c = c^\star$, we re-estimate the tail-risk reductions for the full sample (Table 5) and the corresponding fan charts (Figure 3).[9] Table 3 reports $c^\star$ evaluated at 2021 debt levels. For most of the countries in the sample, $c^\star > 1$ because the primary balance is positively correlated with growth: the values range from 0.8 for Egypt (whose primary balance is weakly negatively correlated with growth) to 2.2 for the Netherlands (where $\rho_{g,pb} = 0.77$). The simulations are performed using the $c^\star$ evaluated at 2021 debt levels. As shown in the Appendix, country-specific coefficients remained fairly stable over time despite changes in the debt-to-GDP ratios (Table A.2).

The gains from using $c^\star$ instead of $c = 1$ depend on how well growth proxies the primary balance (Table 4). For most countries, the R^2 of a regression of the primary balance on growth is low, and the additional variance reduction from the optimal coefficient is modest but not negligible—around 4 percentile points on average. However, for Spain ($R^2 = 0.73$) and Costa Rica ($R^2 = 0.75$), the additional reduction reaches 15 and 17 percentile points,

[8] A 75th-percentile threshold is consistent with the EU's fiscal sustainability framework (European Commission, 2024)

[9] Note that for this set of simulations we set $k_t = \hat{i}_t - c\hat{g}_t$ to ensure similar expected returns and debt paths between the indexed and non-indexed cases.

respectively. These are the countries for which the growth rate is a sufficiently good proxy for fiscal conditions that over-indexation pays off materially (Table 5).

4.4 Takeaways and Robustness

Several conclusions emerge from the previous analysis. Indexed debt reduces the debt-ratio variance, but gains vary significantly across countries and shares of indexed debt, and depend on the co-movements between the relevant macroeconomic variables. Simple $c = 1$ indexation offers partial insurance as it does not directly hedge primary balance fluctuations. Optimal indexation ($c = c^\star$) improves outcomes modestly on average but substantially for countries with tight fiscal-cycle co-movement. Growth-gap indexation (Appendix A.2) provides further improvements in the 15-country subsample with output gap data, but marginal gains over $c^\star$ are typically small, and the formula's complexity and uncertainties in estimating the output gap itself would likely command a higher market premium.

Three important caveats apply to the baseline simulations. First, the empirical covariance matrix is assumed to be stable, whereas it may evolve with structural changes in fiscal policy or the business cycle. Second, sovereigns are assumed to be able to issue bonds with arbitrary formulas, whereas in practice standardization may limit the feasible designs. Third, the primary balance is treated as exogenous: lower interest payments under GIBs would allow for more counter-cyclical fiscal policy. These benefits resulting from fiscal multiplier channels are explored in Demertzis and Zenios (2019) and Kalamov and Zimmermann (2023). However, from a debt-stabilization perspective, this more active use of fiscal policy, with the ability to have higher deficits during bad times, would offset some of the direct hedging benefit on the upper-tail of the distribution.

Robustness checks. Multiple robustness exercises were conducted to assess the sensitivity of the baseline results to key modeling assumptions.

Endogenous interest rates. The baseline assumes that the effective interest rate is exogenous. In practice, higher debt levels increase sovereign risk and thereby borrowing costs. We consider the following specification for the endogenous interest rate:

$$i_t^{\text{end}} = i_t^{\text{base}} + \phi \max(d_{t-1} - d_0, 0), \tag{18}$$

where i_t^{base} is equal to the exogenous i_t for the non-indexed debt and to $\bar{i}_t$ for the indexed debt, with $\phi = 0.03$ calibrated to Laubach (2009). Table A.6 (Appendix) shows the results from this robustness check. The differences relative to the exogenous-rate baseline remain equal or close to 0 for all countries, confirming that the main conclusions are robust to this assumption.

Stochastic k_t. In our main analysis, we treat the contract term k_t as time-varying but pre-determined as a simplifying assumption. This means that k_t is not state-dependent and this implies that any variation in i_t is exactly offset by $\mathbb{E}_{t-1}[g_t]$. We relax this assumption in Appendix A.3 and analyze how a stochastic time-varying k_t would affect the above indexation results and derived optimal indexation coefficient c^*. In order to do so, we assume that growth expectations remain time-varying but pre-determined, while shocks to the interest rate translate one-for-one into the indexed coupon. As shown in Table A.7, this does not change our main results in a significant way, with the indexation benefits becoming on average higher across countries. As shown in Table A.8, the optimal growth indexation coefficient is on average reduced by 0.1 given the empirical positive correlations between i_t and g_t, yet the optimal coefficients remain above 1 for most countries. Finally, the results reported in Table A.9 confirm that the use of the optimal indexation coefficient bring additional benefits in term of tail-risk reductions—around 3 percentiles points on average.

Zero floor on indexed coupons. The baseline specification allows the indexed coupon to turn negative when realized growth is sufficiently low, so that the sovereign effectively receives

net payments from bondholders. While this corresponds to a fully symmetric insurance design, investors may not accept negative coupons in practice. To assess whether a realistic floored instrument still provides tail-risk protection, we consider a *fairly priced* floored bond: the contract term k_t^{adj} is set each period so that the expected coupon equals the expected non-indexed coupon, i.e. $\mathbb{E}[\max(g_t + k_t^{\text{adj}}, 0)] = \hat{i}_t$. Given the i.i.d. normal distribution of growth shocks, k_t^{adj} is solved numerically for each country, period by period, using expected growth from the IMF ($\hat{g}_t$) and the moments from the historical covariance matrix. Results are reported in Table A.10 in Appendix and show that a fairly priced floored bond provides materially less tail-risk protection than the fully symmetric design, especially for high-debt low-growth countries where negative coupons would have the highest insurance value. On average, the upper-tail drops from the 99th to 95th percentile (versus 91st in the baseline), with countries such as Japan or Greece suffering from the largest losses as the constraint is more binding for these countries. Thus, this result suggests the design is important and has strong implication for the debt-stabilizing properties of indexed bonds. In practice, this issue could potentially be solved by reducing the principal repayment in years when the implied coupon would have been negative (International Capital Market Association (ICMA), 2017).

Serial correlation. The benchmark assumes i.i.d. shocks over time. Table A.11 in Appendix reproduces the main result using country-specific VAR(1) in (i_t, g_t, pb_t), allowing each variable to be serially correlated. For most countries, the tail-risk reductions are qualitatively similar, but are on lower in this specification—by around 3 percentiles points on average. For a handful of high-persistence countries (Mexico, Greece), the VAR(1) generates somewhat different dynamics, but the main message remains unchanged.

5 Introducing a Risk Premium

The previous simulations assumed risk-neutral investors and costless contracts. In practice, investors may require a net premium to hold GIBs, due to novelty, illiquidity, and to carry the risks from state-contingent payoffs (Barr et al., 2014, Blanchard et al., 2016). The GDP warrants issued by Argentina in 2005 carried an estimated residual premium of 1,200 basis points at issuance (Chamon et al., 2008, Igan et al., 2021); similar premia were estimated for Greece (2012) and Ukraine (2015). Conversely, GIBs may reduce the probability of default, which compresses default risk premia on all outstanding debt; the net premium ρ captures the balance of these opposing forces. The indexed interest rate under a net premium ρ is:

$$\bar{i}_t = g_t + k_t + \rho. \tag{19}$$

A positive ρ shifts the entire baseline debt trajectory upward, partly or fully offsetting the variance reduction. Figure 4 shows fan charts under a 100-basis-point net premium for selected countries. The break-even premium $\bar{\rho}$—the largest ρ at which indexation still reduces the nth percentile of the debt distribution—is:

$$\bar{\rho} = \left(\frac{d_t^n}{d_0}\right)^{1/t} - \left(\frac{d_t^{n,*}}{d_0}\right)^{1/t}, \tag{20}$$

where d_t^n and $d_t^{n,*}$ are the $n-$th percentiles of the non-indexed and indexed distributions at horizon t, and d_0 is the 2021 debt ratio.

Table 6 reports $\bar{\rho}$ for the 99th and 75th percentiles at 10-year and 20-year horizons under full indexation with $c = 1$. The break-even premia are low for most countries—well below 100 basis points at the 10-year horizon for the 75th percentile—but substantially higher for a few high-variance countries. Spain, Mexico, and Japan retain positive net benefits at premia above 100 basis points at the 99th-percentile threshold (10-year horizon), but this

advantage erodes at the 75th-percentile or 20-year horizons. Put differently, for advanced economies with debt-to-GDP ratios near 100 percent, a sustained net annual premium of around 1 percent of GDP would be more than enough to eliminate the insurance value of GIBs—a threshold well below the premia observed in past GIB issuances.

Two additional points are worth noting. First, premia on growth-linked instruments are likely to be countercyclical as investors may demand higher compensation during recessions, exactly when the sovereign most benefits from the insurance (Mouabbi et al., 2024). Second, as shown by Moretti (2020), a small share of indexed debt may face a liquidity discount that increases with the degree of market incompleteness, limiting the gains from partial issuance.

6 Conclusion

This paper asks a simple question: when is growth-indexed bond issuance "too little" or "too costly" to deliver meaningful debt-stabilization benefits? Three findings stand out.

First, simple growth indexation ($c = 1$) does not provide complete insurance in terms of debt stabilization because it does not directly hedge primary balance fluctuations. The median tail-risk reduction under full growth indexation corresponds to a shift from a 9 percent to a 1 percent tail probability—economically meaningful, but with heterogeneous effects across countries. Growth indexation using an optimal coefficient ($c = c^\star > 1$) improves outcomes more substantially for countries where growth is a strong proxy for fiscal conditions. Thus, a possibility for some sovereigns if growth-indexed bonds are successfully issued, would be to issue growth-indexed bonds with different indexation coefficients in order to have a portfolio of indexed debt with an indexation coefficient remaining close to the optimal coefficient c_t^* over time. Second, the share of indexed debt is critical. Indexing 20 percent of the debt stock—already above the share of inflation-indexed bonds in most countries—generates negligible tail-risk reduction at the 99th percentile for all countries in the sample.

Only a coordinated initiative, involving a sufficiently large share of sovereign debt, would deliver substantial gains. Third, this paper finds that the size of the premium is crucial. A premium of 100 basis points, in line with the findings in the literature, and even lower for some countries, may cancel the potential benefits from indexation.

As such, under reasonable assumptions, the benefits from growth-indexed bonds in terms of debt stabilization are much lower than traditionally assumed. The difficulties to issue a large share of indexed bonds, combined with an implicit high premium required by investors, provide an explanation for the apparent non-contingency puzzle.

These findings are consistent with Demertzis and Zenios (2019), who attribute non-adoption to coordination failures and first-mover problems: no single sovereign gains enough from unilateral issuance to justify the effort, but a coordinated shift by multiple advanced economies could alter the equilibrium. They are also consistent with Mouabbi et al. (2024), who find that endogenous time-varying risk premia eliminate the debt-stabilization benefits of GIBs in a structural macro-finance model. The present paper's reduced-form framework complements these structural results by providing closed-form expressions for the key design parameters and enabling cross-country comparisons across a broad sample.

Several avenues remain open for future research. An extension is to allow the primary balance to respond to indexation-induced savings, capturing the fiscal multiplier effects emphasized by Demertzis and Zenios (2019) and Kalamov and Zimmermann (2023). Another is to model the interaction between GIB issuance and monetary policy, particularly in monetary unions where the external discipline on fiscal policy plays a central role. Finally, the analysis of market liquidity and determination of the novelty premium—as in Moretti (2020)—could sharpen the quantitative assessment of the maximum acceptable premium.

In conclusion, there might still be a case for issuing growth-linked bonds in some countries, but their benefits in terms of debt ratio stabilization would remain elusive unless they are issued at both a substantially large scale and low premium.

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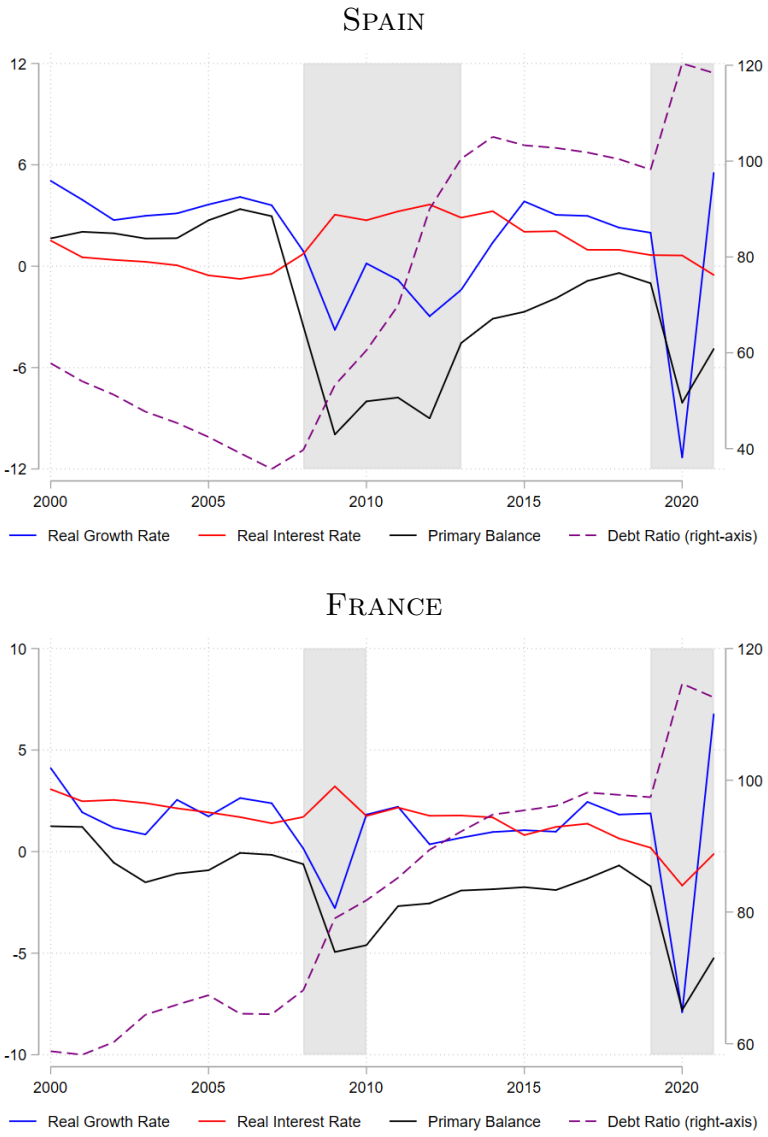
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Tables and Figures

Figure 1 Real Interest Rate, Growth, Primary Balance, and Debt Ratio — Spain and France (2000–2021)



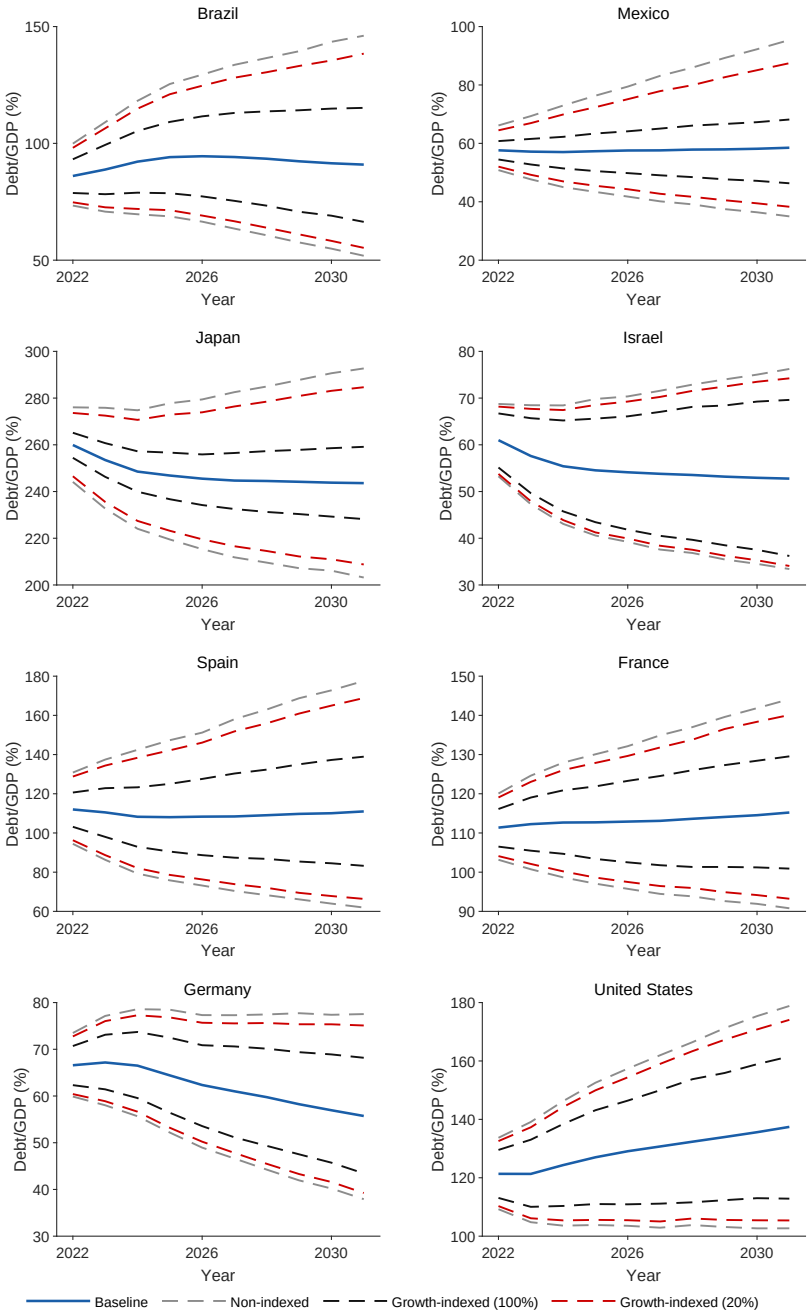
Note. The charts show the annual real GDP growth rate, the real effective interest rate (net interest payments divided by lagged debt), the primary balance (surplus) as a percent of GDP, and the debt-to-GDP ratio for Spain (upper panel) and France (lower panel), 2000–2021. Shaded areas denote years around a recession. Source: IMF WEO, April 2023.

Table 1 Descriptive Statistics by Country (1996–2021)

Country	d_{2021}	var$(i-g)$	var(pb)	corr$(pb, i-g)$	corr(pb, g)	corr(pb, i)	corr(i, g)
United States	126.4	7.3	12.8	−0.31	0.41	0.37	0.13
United Kingdom	108.1	5.6	11.8	−0.47	0.66	0.53	0.45
Austria	82.3	5.2	4.4	−0.24	0.45	0.37	0.19
Belgium	109.2	7.1	11.7	0.14	0.38	0.84	0.13
France	112.6	6.1	4.5	−0.24	0.57	0.63	0.30
Germany	68.6	8.5	3.3	−0.31	0.34	−0.12	−0.22
Italy	149.8	7.8	6.9	−0.07	0.42	0.67	0.45
Netherlands	52.4	6.1	5.5	−0.53	0.77	0.53	0.49
Sweden	36.3	6.8	3.5	−0.12	0.48	0.52	0.11
Canada	115.1	16.2	12.8	−0.04	0.36	0.66	0.06
Japan	255.4	4.5	5.3	−0.53	0.51	−0.17	0.01
Greece	200.7	28.2	14.2	−0.24	0.27	0.16	0.58
Malta	55.1	28.6	9.8	−0.34	0.35	−0.02	−0.04
Portugal	125.4	11.9	6.9	−0.47	0.42	−0.02	0.43
Spain	118.4	18.1	16.7	−0.80	0.86	0.37	0.41
Türkiye	41.8	85.5	6.5	0.26	0.27	0.59	0.64
Australia	57.6	15.9	7.2	−0.21	0.38	0.08	−0.27
South Africa	69.0	9.1	5.5	−0.66	0.81	0.70	0.61
Argentina	80.9	326.7	8.6	0.25	−0.31	−0.25	−0.43
Brazil	90.7	24.2	10.5	−0.28	0.66	0.56	0.05
Chile	36.3	24.4	12.7	−0.40	0.38	−0.06	0.28
Colombia	64.0	22.1	3.5	−0.12	0.23	0.21	0.46
Costa Rica	68.0	16.3	4.8	−0.75	0.86	0.80	0.84
Mexico	58.7	38.1	1.7	0.18	−0.13	0.20	0.51
Peru	36.4	38.6	6.7	−0.59	0.59	−0.26	−0.42
Israel	68.0	7.8	6.3	−0.25	0.47	0.26	0.08
Egypt	89.9	36.7	10.4	0.28	−0.29	−0.06	0.29
India	84.7	19.2	3.3	−0.29	0.36	0.42	−0.12
Indonesia	41.1	38.8	3.9	−0.70	0.72	−0.08	−0.33
Korea	51.3	14.8	2.6	0.16	0.61	0.68	0.42
Cameroon	46.8	3.0	48.5	−0.03	0.07	0.07	0.23

Note. The table reports descriptive statistics by country. d_{2021}: Debt-to-GDP ratio in 2021; var(i-g): Variance of the difference between the nominal implicit interest rate and the nominal GDP growth rate; var(pb): Variance of the primary balance as a share of GDP; corr(pb,i-g): Correlation between the primary balance as a share of GDP and the difference between the nominal implicit interest rate and the nominal GDP growth rate; corr(pb,g): Correlation between the primary balance as a share of GDP and the nominal GDP growth rate; corr(pb,i): Correlation between the primary balance as a share of GDP and the nominal implicit interest rate; corr(i,g): Correlation between the nominal implicit interest rate and the nominal GDP growth rate. Source: IMF WEO Database, April 2023 and author's calculations.

Figure 2 Debt/GDP Ratio Forecasts for Different Shares of Growth-indexed Debt — Selected Countries



Note. Dashed lines show the 1st and 99th percentiles of the simulated debt/GDP distribution: grey for non-indexed debt, black for full growth indexation (100% indexed debt), and red for partial growth indexation (20% indexed debt). The blue solid line is the baseline scenario using IMF projections. Source: Author's calculations.

Table 2 Percentile of the Non-indexed Distribution Corresponding to the 99th and 75th Percentiles of the Indexed Distribution — Simple GIBs ($c = 1$), 10-Year Horizon

Country	99th percentile		75th percentile	
	100%	20%	100%	20%
United States	92	98	65	73
United Kingdom	93	98	67	73
Austria	94	98	68	73
Belgium	96	98	70	73
France	89	97	64	72
Germany	92	98	66	73
Italy	89	97	64	72
Netherlands	95	98	69	74
Sweden	97	98	72	74
Canada	93	98	67	73
Japan	78	97	58	71
Greece	79	97	57	71
Malta	91	98	66	73
Portugal	86	98	63	72
Spain	86	98	62	72
Türkiye	98	98	73	74
Australia	94	98	68	73
South Africa	90	98	64	73
Argentina	98	98	71	74
Brazil	87	98	63	72
Chile	96	98	71	74
Colombia	89	97	64	72
Costa Rica	86	98	62	72
Mexico	76	97	56	70
Peru	91	98	66	73
Israel	96	98	70	73
Egypt	95	97	69	72
India	82	97	60	71
Indonesia	87	98	63	72
Korea	95	98	71	73
Cameroon	98	98	74	74

Note. Each number represents the percentile of the non-indexed distribution whose debt/GDP level equals the indicated percentile of the indexed distribution (either 99-th or 75-th), assuming either full (100%) or partial (20%) indexation of the stock of debt, after 10 years. A lower number indicates a larger tail-risk reduction: for the United States, full indexation reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 92nd percentile of the non-indexed distribution—equivalent to reducing a 8 percent tail probability to 1 percent. Specification with i.i.d. shocks; 10,000 Monte Carlo draws. Source: Author's calculations.

Table 3 Optimal Indexation Coefficient c^* to the Nominal Growth Rate

Country	c^*
United States	1.4
United Kingdom	1.8
Austria	1.5
Belgium	1.5
France	1.4
Germany	1.4
Italy	1.2
Netherlands	2.2
Sweden	2.1
Canada	1.3
Japan	1.2
Greece	1.1
Malta	1.4
Portugal	1.2
Spain	1.6
Türkiye	1.1
Australia	1.7
South Africa	1.8
Argentina	0.9
Brazil	1.6
Chile	1.8
Colombia	1.1
Costa Rica	1.5
Mexico	1.0
Peru	1.7
Israel	1.7
Egypt	0.8
India	1.2
Indonesia	1.6
Korea	1.6
Cameroon	1.6

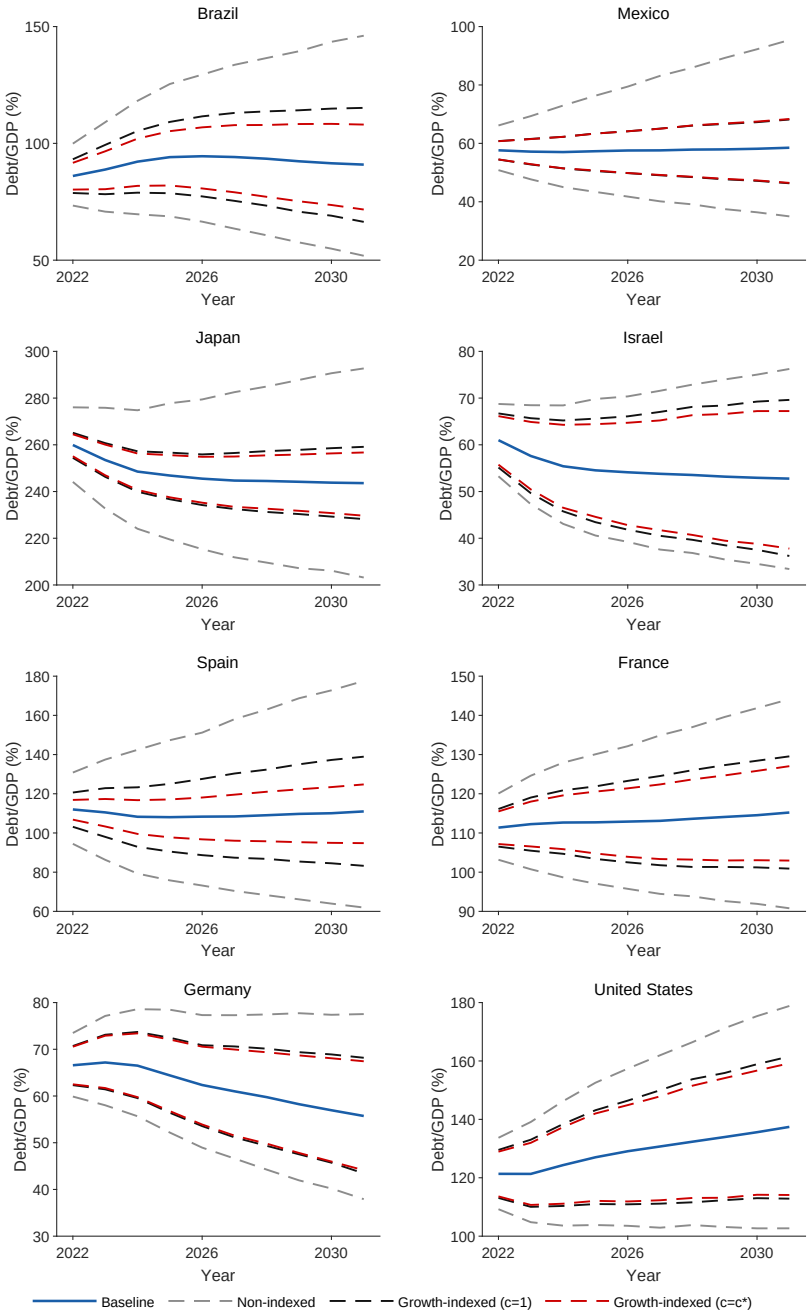
Note. This table reports the optimal indexation coefficient from equation (15), evaluated at 2021 debt levels and assuming all debt is indexed ($X = 1$). Source: Author's calculations.

Table 4 R^2 of Country-Specific Regressions of Primary Balance on Growth and Output Gap

Country	R^2 (Growth)	R^2 (Growth + Gap)
United States	0.16	0.23
United Kingdom	0.44	0.53
Austria	0.20	0.42
Belgium	0.14	0.25
France	0.33	0.55
Germany	0.12	0.45
Italy	0.18	0.24
Netherlands	0.59	0.61
Sweden	0.23	0.47
Canada	0.13	0.48
Japan	0.26	0.60
Greece	0.07	0.28
Malta	0.12	0.28
Portugal	0.18	0.19
Spain	0.73	0.76
Türkiye	0.07	—
Australia	0.15	—
South Africa	0.66	—
Argentina	0.09	—
Brazil	0.44	—
Chile	0.14	—
Colombia	0.05	—
Costa Rica	0.75	—
Mexico	0.02	—
Peru	0.35	—
Israel	0.22	—
Egypt	0.08	—
India	0.13	—
Indonesia	0.51	—
Korea	0.37	—
Cameroon	0.00	—

Note. The table reports the R^2 statistic from OLS regressions of pb_t on g_t (and additionally z_t for the 15-country subsample with output gap data). Source: IMF WEO, April 2023, and author's calculations.

Figure 3 Debt/GDP Ratio Forecasts — Growth-indexed Debt with Different Indexation Coefficients, Selected Countries



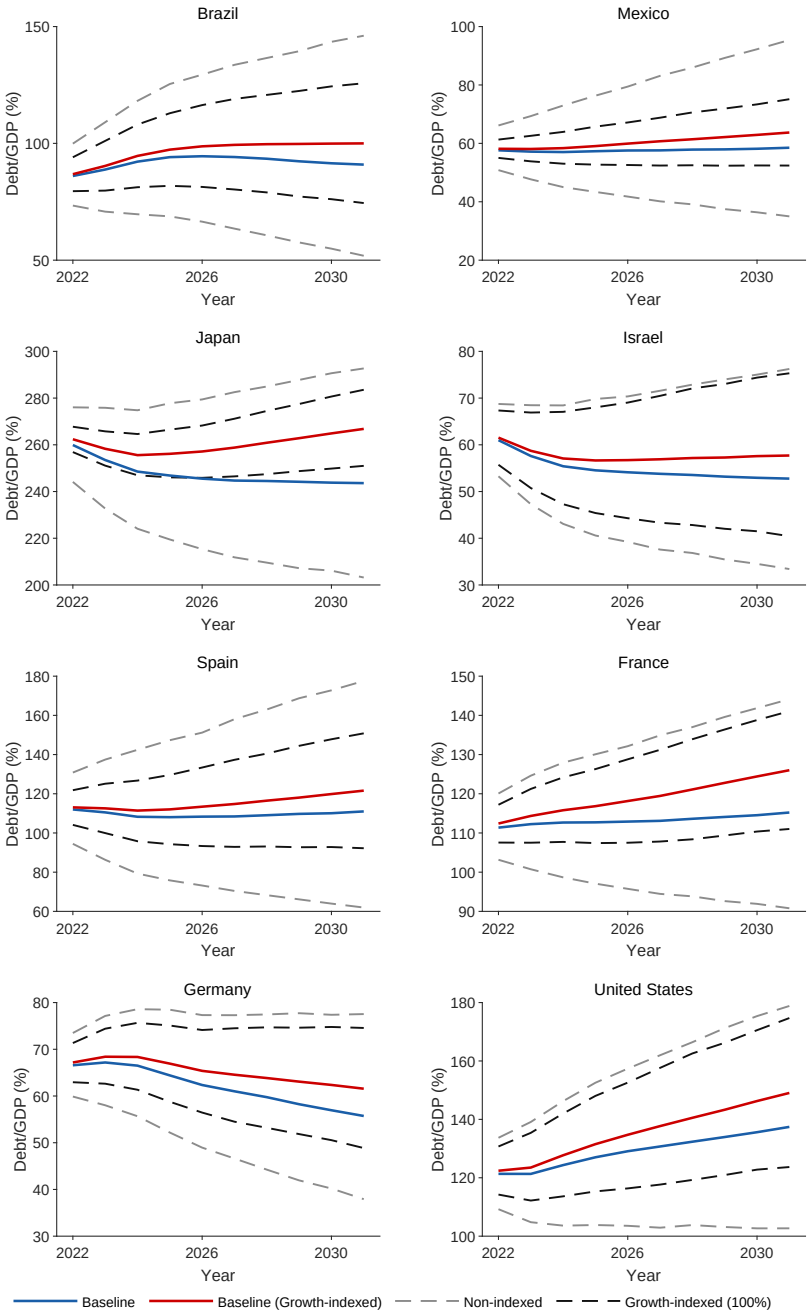
Note. Grey dashed lines: 1st and 99th percentiles, non-indexed. Black dashed lines: 1st and 99th percentiles, $c = 1$ (full indexation). Red dashed lines: 1st and 99th percentiles, $c = c^*$ (full indexation, optimal coefficient). The blue solid line is the baseline scenario using IMF projections. Source: Author's calculations.

Table 5 Tail-Risk Reduction: $c = 1$ vs. $c = c^*$, 10-Year Horizon

Country	99th percentile			75th percentile		
	$c = 1$	$c = c^*$	Diff.	$c = 1$	$c = c^*$	Diff.
United States	92	90	−2	65	63	−2
United Kingdom	93	87	−6	67	63	−4
Austria	94	92	−2	68	66	−2
Belgium	96	95	−1	70	68	−2
France	89	84	−5	64	61	−3
Germany	92	90	−2	66	65	−1
Italy	89	87	−2	64	62	−2
Netherlands	95	86	−9	69	62	−7
Sweden	97	96	−1	72	69	−3
Canada	93	91	−2	67	64	−3
Japan	78	75	−3	58	57	−1
Greece	79	78	−1	57	56	−1
Malta	91	90	−1	66	64	−2
Portugal	86	84	−2	63	61	−2
Spain	86	71	−15	62	55	−7
Türkiye	98	97	−1	73	71	−2
Australia	94	92	−2	68	66	−2
South Africa	90	76	−14	64	56	−8
Argentina	98	98	0	71	72	+1
Brazil	87	79	−8	63	58	−5
Chile	96	95	−1	71	69	−2
Colombia	89	88	−1	64	64	0
Costa Rica	86	69	−17	62	53	−9
Mexico	76	77	+1	56	56	0
Peru	91	85	−6	66	61	−5
Israel	96	93	−3	70	67	−3
Egypt	95	95	0	69	68	−1
India	82	80	−2	60	58	−2
Indonesia	87	77	−10	63	57	−6
Korea	95	91	−4	71	66	−5
Cameroon	98	98	0	74	74	0

Note. The table reports the percentile of the non-indexed distribution corresponding to the 99th or 75th percentile of the indexed distribution, under full ($X = 1$) indexation with coefficient $c = 1$ and with the optimal coefficient c^*. Specification with i.i.d. shocks; 10-year horizon. The "Diff." column corresponds to the difference between columns c^* and $c = 1$; negative values indicate larger reductions under the optimal coefficient. For the United States, full indexation using the optimal coefficient c^* reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 90th percentile of the non-indexed distribution—equivalent to reducing a 10 percent tail probability to 1 percent. Source: Author's calculations.

Figure 4 Debt/GDP Ratio Forecasts — Growth-indexed Debt with a 100-Basis-Point Net Premium, Selected Countries



Note. Grey dashed lines: 1st and 99th percentiles, non-indexed. Black dashed lines: 1st and 99th percentiles, fully indexed ($c = 1$, 100 bp premium). The blue solid line is the baseline scenario using IMF projections.; the red solid line is the indexed baseline (shifted upward by the net premium). Source: Author's calculations.

Table 6 Maximum Acceptable Net Premium on Growth-indexed Bonds (percent per annum), $c = 1$, Full Indexation

Country	10-year		20-year	
	99th	75th	99th	75th
United States	1.05	0.29	0.71	0.21
United Kingdom	1.02	0.28	0.66	0.19
Austria	0.84	0.22	0.56	0.16
Belgium	0.51	0.13	0.38	0.11
France	1.09	0.29	0.76	0.22
Germany	1.29	0.37	0.90	0.26
Italy	1.23	0.34	1.00	0.29
Netherlands	1.01	0.27	0.58	0.17
Sweden	0.56	0.16	0.34	0.14
Canada	1.37	0.35	0.78	0.24
Japan	1.23	0.35	0.85	0.25
Greece	3.03	0.91	2.26	0.75
Malta	2.24	0.60	1.44	0.43
Portugal	1.91	0.53	1.41	0.43
Spain	2.52	0.72	1.68	0.51
Türkiye	0.48	0.13	0.36	0.15
Australia	1.42	0.39	0.96	0.25
South Africa	1.65	0.49	1.30	0.38
Argentina	0.36	0.00	0.82	0.00
Brazil	2.46	0.67	1.86	0.53
Chile	1.74	0.44	1.00	0.29
Colombia	2.01	0.55	1.46	0.43
Costa Rica	2.75	0.89	2.18	0.81
Mexico	3.47	1.08	2.81	0.95
Peru	3.25	0.93	2.17	0.73
Israel	0.91	0.23	0.58	0.16
Egypt	1.35	0.42	0.96	0.44
India	1.95	0.55	1.30	0.39
Indonesia	3.49	1.03	2.49	0.74
Korea	0.91	0.17	0.48	0.10
Cameroon	0.06	0.01	0.04	0.04

Note. The table reports the maximum net annual premium $\bar{\rho}$ (equation 20) such that the indicated percentile of the indexed debt distribution equals the same percentile of the non-indexed distribution. For the United States, a sustained net premium of 105 basis points would equalize the 99-th percentile tails of the indexed and non-indexed debt distributions after 10 years. Full indexation ($X = 1$), assuming $c = 1$, specification with i.i.d. shocks. Source: Author's calculations.

A Appendix

A.1 An Horizon Invariance Equivalence Result

The closed-form formulas in the main text minimize the one-period-ahead conditional variance $\mathrm{Var}_{t-1}(\Delta d_t)$. A natural question is whether the same hedge ratios also minimize the variance at longer horizons. The following proposition shows that they do, under local linearization and conditional serial independence, provided the contract terms are predetermined at date $t-1$.

Proposition 1 (Horizon invariance) *Fix $h \geq 1$. Suppose:*

(i) *Local linearization:* $\max_{0\leq j\leq h-1} |d_{t+j-1} - d_{t-1}| = o_p(1)$.

(ii) *Predetermined contract terms:* $\{k_{t+j}\}_{j=0}^{h-1} \subset \mathcal{F}_{t-1}$.

(iii) *Conditional serial independence: conditional on $\mathcal{F}_{t-1}$, the vectors $(i_{t+j}, g_{t+j}, pb_{t+j})$ are serially independent and identically distributed for $j = 0, \ldots, h-1$.*

(iv) *Negligible linearization errors:* $\mathrm{Var}_{t-1}(\epsilon_{t,h}) = o(1)$.

Define the one-period conditional variance for policy (X, c) as:

$$V_{t-1}(X,c) \;\equiv\; \mathrm{Var}_{t-1}(pb_t) + d_{t-1}^2 \,\mathrm{Var}_{t-1}((1-X)i_t - (1-cX)g_t) - 2d_{t-1}\,\mathrm{Cov}_{t-1}(pb_t,\,(1-X)i_t - (1-cX)g_t) \tag{A.1}$$

Note that $V_{t-1}(X,1) = \mathrm{Var}_{t-1}(\Delta d_t)$ from equation (7). Then for any admissible (X,c):

$$\mathrm{Var}_{t-1}(d_{t+h-1}) = h\, V_{t-1}(X,c) + o(1). \tag{A.2}$$

Consequently,

$$\arg\min_{X,c}\; \mathrm{Var}_{t-1}(d_{t+h-1}) \;=\; \arg\min_{X,c}\; V_{t-1}(X,c). \tag{A.3}$$

Proof. Summing the debt accumulation equation over $j = 0, \ldots, h-1$ and applying the local linearization of condition (i) to replace each d_{t+j-1} with d_{t-1}:

$$d_{t+h-1} = d_{t-1} + \underbrace{\sum_{j=0}^{h-1} X k_{t+j}\, d_{t-1}}_{\in \mathcal{F}_{t-1}} + \sum_{j=0}^{h-1} u_{t+j}(X,c) + \epsilon_{t,h}, \tag{A.4}$$

where $u_{t+j}(X,c) \equiv d_{t-1}[(1-X)i_{t+j} - (1-cX)g_{t+j}] - pb_{t+j}$ is the zero-mean stochastic component, and $\epsilon_{t,h}$ collects the linearization errors with $\mathrm{Var}_{t-1}(\epsilon_{t,h}) = o(1)$ by condition (iv). Taking $\mathcal{F}_{t-1}$-conditional variances, the $\mathcal{F}_{t-1}$-measurable term drops out:

$$\mathrm{Var}_{t-1}(d_{t+h-1}) = \mathrm{Var}_{t-1}\left(\sum_{j=0}^{h-1} u_{t+j}\right) + o(1). \tag{A.5}$$

Expanding the right-hand side, the cross-period terms vanish by condition (iii) (serial independence), and each diagonal term equals $V_{t-1}(X,c)$ by condition (iii) (identical distribution):

$$\mathrm{Var}_{t-1}(d_{t+h-1}) = \sum_{j=0}^{h-1} V_{t-1}(X,c) + o(1) = h\, V_{t-1}(X,c) + o(1). \tag{A.6}$$

Since $h > 0$, minimizing over (X,c) is equivalent to minimizing $V_{t-1}(X,c)$. ■

Proposition 1 does not require k_t to be constant over calendar time; conditions (i)–(iv) are sufficient. The result fails under serial correlation in shocks, time-varying conditional second moments, or endogenous repricing of long-maturity issuance. In those settings, the one-period formulas remain useful analytical benchmarks but should not be interpreted as exact long-horizon policy rules.

A.2 Growth-Gap Indexed Bonds

For the subsample with output gap data, we extend the analysis to a growth-gap indexed coupon:

$$\bar{i}_t = a\, g_t + b\, z_t + k_t, \tag{A.7}$$

where z_t is the output gap. The debt dynamics with indexed share $X = 1$ become:

$$\Delta d_t = \big[(a-1)g_t + b\, z_t + k_t\big] d_{t-1} - pb_t. \tag{A.8}$$

The variance-minimizing coefficients satisfy:

$$a^\star = 1 + \frac{\mathrm{Cov}(pb, g)\,\mathrm{Var}(z) - \mathrm{Cov}(pb, z)\,\mathrm{Cov}(z, g)}{d_{t-1}\big[\mathrm{Var}(g)\,\mathrm{Var}(z) - \mathrm{Cov}(z, g)^2\big]}, \tag{A.9}$$

$$b^\star = \frac{\mathrm{Cov}(pb, z)\,\mathrm{Var}(g) - \mathrm{Cov}(pb, g)\,\mathrm{Cov}(z, g)}{d_{t-1}\big[\mathrm{Var}(g)\,\mathrm{Var}(z) - \mathrm{Cov}(z, g)^2\big]}. \tag{A.10}$$

When $\rho_{g,z} = 0$, the minimum achievable conditional variance is:

$$\mathrm{Var}_{t-1}(\Delta d_t) = \mathrm{Var}_{t-1}(pb_t)\big(1 - \rho^2_{g,pb} - \rho^2_{z,pb}\big)\,. \tag{A.11}$$

A large $|\rho_{g,z}|$ renders the output gap redundant once growth is already in the formula, while large $|\rho_{z,pb}|$ makes the output gap a valuable additional hedge.

Table A.3 reports the optimal coefficients $(a^\star, b^\star)$ for the 15-country subsample. Table A.4 reports $\mathrm{corr}(g, z)$, which averages 0.62 across the subsample impliying that indexing to the output gap adds only modest incremental benefit once growth is already included. Table A.5 confirms this quantitatively: the gain from switching to the growth-gap formula (compared with $c = c^\star$, growth only) averages about 2 percentile points.

A.3 Stochastic k_t and Optimal Indexation

In the analytical derivations in the main text, $k_t = i_t - \mathbb{E}_{t-1}[g_t]$ is treated as known at $t-1$, so that it does not enter the one-period-ahead conditional variance. This subsection considers the more general case in which k_t is not $\mathcal{F}_{t-1}$-measurable and therefore enters stochastically into $\mathrm{Var}_{t-1}(\Delta d_t)$. Under the more general coupon formula $\bar{i}_t = c\, g_t + k_t$ with $X = 1$, the debt dynamics simplify to:

$$\Delta d_t = \big[k_t - (1-c)\, g_t\big] d_{t-1} - p b_t, \tag{A.12}$$

and the conditional variance reduces to:

$$\mathrm{Var}_{t-1}(\Delta d_t) = \mathrm{Var}_{t-1}(p b_t) + d_{t-1}^2 \,\mathrm{Var}_{t-1}(k_t + (c-1) g_t) - 2 d_{t-1}\,\mathrm{Cov}_{t-1}(p b_t,\, k_t + (c-1) g_t)\,. \tag{A.13}$$

Minimizing with respect to c yields the optimal growth loading:

$$c^{\star}_{t-1} = 1 + \frac{\mathrm{Cov}_{t-1}(p b_t,\, g_t)}{d_{t-1}\,\mathrm{Var}_{t-1}(g_t)} - \frac{\mathrm{Cov}_{t-1}(k_t,\, g_t)}{\mathrm{Var}_{t-1}(g_t)}. \tag{A.14}$$

Compared to the baseline formula (15), the only additional term is $-\mathrm{Cov}_{t-1}(k_t,\, g_t)\,/\mathrm{Var}_{t-1}(g_t)$.

In order to study the implication of a stochastic k_t, we set

$$k_t \;=\; i_t - \hat{g}_t, \tag{A.15}$$

so that interest-rate shocks translate one-for-one into the indexed coupon. Substituting $\mathrm{Cov}_{t-1}(k_t, g_t) = \mathrm{Cov}(i_t, g_t)$ into equation (A.14), the optimal growth indexation coefficient becomes:

$$c_t^{\star,k} \;=\; 1 + \frac{\mathrm{Cov}(g_t,\, p b_t)}{d_{t-1}\,\mathrm{Var}(g_t)} \;-\; \frac{\mathrm{Cov}(i_t,\, g_t)}{\mathrm{Var}(g_t)}. \tag{A.16}$$

The only difference from equation (15) is the additional term $-\text{Cov}(i_t, g_t)/\text{Var}(g_t)$. Because $\text{Cov}(i_t, g_t) > 0$ for 24 of 31 countries, $c^{\star,k} < c^{\star}$ for most countries in the sample, with an average reduction of 0.1 (Table A.8).

Tables A.7–A.9 present the quantitative results for all 31 countries. As shown in Table A.7, for most countries (21 of 31) the tail-risk reduction is the same or larger under stochastic k_t than in the baseline: the interest-rate shock now enters both the indexed coupon (through $k_t = i_t - \hat{g}_t$) and the plain-vanilla coupon, partially offsetting each other in the relative comparison. The average change across countries is an improvement in the tail by about 2 percentile points.

Taken together, the three tables confirm that the paper's main conclusions are robust to allowing stochastic variation in k_t.

A.4 Vector Autoregression with One Lag

As a robustness check, a 3-variable VAR(1) in (i_t, g_t, pb_t) is estimated for each country using annual data from 1996 to 2021. At each simulation step, the VAR's intercept is adjusted to align the conditional mean with the corresponding IMF WEO forecast while holding the slope coefficients and error covariance matrix fixed. Results are reported in Table A.11.

Appendix – Tables

Table A.1 Pre-determined Contract Term $k_t = \hat{i}_t - \hat{g}_t$, 2022–2029

Country	2022	2023	2024	2025	2026	2027	2028	2029
United States	−7.4	−3.3	−1.0	−1.3	−1.6	−1.6	−1.6	−1.6
United Kingdom	−5.8	−2.2	−2.3	−2.2	−2.3	−2.1	−2.0	−2.0
Austria	−9.3	−7.1	−2.3	−2.3	−1.5	−2.4	−1.3	−1.3
Belgium	−8.7	−3.9	−1.7	−0.9	−0.9	−0.7	−0.8	−0.8
France	−4.0	−2.6	−2.4	−2.4	−1.6	−1.2	−0.8	−0.8
Germany	−6.5	−3.6	−2.7	−3.1	−2.9	−1.5	−1.4	−1.4
Italy	−3.8	−3.9	0.0	−0.3	−0.1	−0.1	0.1	0.1
Netherlands	−9.6	−7.3	−6.1	−3.8	−3.1	−2.7	−2.7	−2.7
Sweden	−7.4	−5.4	−2.7	−3.7	−3.3	−3.3	−3.3	−3.3
Canada	−11.5	−2.2	−4.0	−4.3	−4.2	−4.1	−4.3	−4.3
Japan	−1.2	−5.1	−3.6	−1.9	−1.7	−1.5	−1.5	−1.5
Greece	−13.1	−5.6	−2.8	−2.0	−1.6	−1.2	−1.2	−1.2
Malta	−10.2	−6.0	−4.2	−3.3	−3.2	−3.0	−3.1	−3.1
Portugal	−9.8	−3.1	−2.6	−2.4	−2.0	−1.7	−1.7	−1.7
Spain	−8.3	−3.7	−3.2	−1.8	−1.2	−1.0	−0.9	−0.9
Türkiye	−100.9	−37.3	−26.7	−15.8	−11.3	−11.4	−11.8	−11.8
Australia	−9.9	1.7	1.0	−2.2	−2.1	−2.1	−2.0	−2.0
South Africa	−0.1	2.4	1.5	2.5	3.0	3.0	3.0	3.0
Argentina	−74.1	−93.7	−56.5	−44.6	−38.9	−33.4	−28.4	−28.4
Brazil	−4.2	0.9	2.9	1.4	0.8	0.6	0.7	0.7
Chile	−10.4	−9.8	−4.9	−3.9	−3.7	−4.2	−4.5	−4.5
Colombia	−14.8	−1.6	0.8	0.1	−0.7	−1.0	−1.5	−1.5
Costa Rica	−2.5	2.7	1.6	1.3	0.9	0.7	0.4	0.4
Mexico	−2.1	−0.7	2.6	3.6	3.6	3.3	2.9	2.9
Peru	−4.4	−3.7	−1.2	−1.4	−1.8	−2.1	−2.2	−2.2
Israel	−7.4	−4.4	−2.9	−2.9	−2.6	−2.4	−2.3	−2.3
Egypt	−9.6	−14.2	−8.2	−1.2	−1.2	−1.3	−1.3	−1.3
India	−8.9	−4.9	−3.9	−3.5	−3.3	−3.1	−3.1	−3.1
Indonesia	−9.9	−3.9	−2.0	−1.5	−1.5	−1.4	−1.5	−1.5
Korea	−4.3	−4.5	−5.2	−4.5	−4.2	−4.2	−4.2	−4.2
Cameroon	−5.9	−6.8	−6.1	−4.8	−3.9	−3.9	−3.9	−3.9

Note. $k_t = \hat{i}_t - \hat{g}_t$, where $\hat{i}_t$ and $\hat{g}_t$ are the baseline forecasts from the IMF WEO April 2023 database for the nominal interest rate and nominal growth rate, respectively. This choice ensures that the expected indexed coupon equals the expected nominal coupon in each period forecasts. The variable k_t is extended at the 2028 level from 2029 onward. Source: April 2023 IMF WEO Database, Author's calculations.

Table A.2 Time-varying Optimal Coefficient c_t^*, 2017–2021

Country	2017	2018	2019	2020	2021
United States	1.5	1.5	1.5	1.5	1.4
United Kingdom	2.0	2.0	2.0	2.0	1.8
Austria	1.5	1.5	1.6	1.6	1.5
Belgium	1.5	1.5	1.6	1.6	1.5
France	1.5	1.5	1.5	1.5	1.4
Germany	1.4	1.5	1.5	1.5	1.4
Italy	1.3	1.3	1.3	1.3	1.2
Netherlands	2.0	2.1	2.2	2.3	2.2
Sweden	1.9	2.0	2.0	2.1	2.0
Canada	1.4	1.4	1.4	1.4	1.3
Japan	1.2	1.2	1.2	1.2	1.2
Greece	1.1	1.1	1.1	1.1	1.1
Malta	1.4	1.4	1.5	1.5	1.4
Portugal	1.2	1.2	1.2	1.3	1.2
Spain	1.7	1.7	1.8	1.8	1.6
Türkiye	1.2	1.2	1.2	1.2	1.2
Australia	2.0	1.9	1.9	1.8	1.7
South Africa	2.1	2.1	2.0	1.9	1.8
Argentina	0.9	0.9	0.9	0.9	1.0
Brazil	1.6	1.6	1.6	1.6	1.5
Chile	2.4	2.2	2.1	2.0	1.9
Colombia	1.2	1.2	1.2	1.2	1.1
Costa Rica	1.7	1.7	1.6	1.6	1.5
Mexico	1.0	1.0	1.0	1.0	1.0
Peru	2.1	2.0	2.0	2.0	1.7
Israel	1.8	1.8	1.8	1.9	1.7
Egypt	0.8	0.9	0.8	0.8	0.8
India	1.2	1.2	1.2	1.2	1.2
Indonesia	1.8	1.8	1.8	1.8	1.6
Korea	1.7	1.7	1.7	1.7	1.6
Cameroon	1.8	1.7	1.7	1.6	1.6

NOTE. This table reports the optimal indexation coefficient from equation (15), re-evaluated annually using the actual debt level in each year and assuming all debt is indexed ($X = 1$). All conditional moments use the full-sample (1996–2021) covariance matrix. Source: Author's calculations.

Table A.3 Optimal Coefficients (a^*, b^*) for Growth-Gap Indexed Bonds — 15-Country Subsample

Country	a^*	b^*
United States	1.2	0.3
United Kingdom	1.5	0.7
Austria	1.3	1.1
Belgium	1.1	1.0
France	1.1	0.7
Germany	0.8	1.3
Italy	1.2	0.2
Netherlands	2.0	0.5
Sweden	1.1	1.7
Canada	1.0	1.6
Japan	1.1	0.4
Greece	1.3	−0.2
Malta	1.0	1.4
Portugal	1.3	−0.1
Spain	1.5	0.2

Note. Optimal coefficients from equations (A.9)–(A.10), evaluated at 2021 debt levels and assuming all debt is indexed ($X = 1$). Source: Author's calculations.

Table A.4 Correlation Between Nominal Growth Rate and Output Gap — 15-Country Subsample

Country	$\text{corr}(g, z)$
United States	0.57
United Kingdom	0.56
Austria	0.44
Belgium	0.68
France	0.63
Germany	0.62
Italy	0.54
Netherlands	0.68
Sweden	0.67
Canada	0.54
Japan	0.51
Greece	0.83
Malta	0.64
Portugal	0.68
Spain	0.67

Note. The table reports the correlation between the country-specific nominal growth rate and output gap over the sample period 1996–2021. Source: IMF WEO, April 2023, and author's calculations.

Table A.5 Additional Tail-Risk Reduction from Growth-Gap Formula vs. Growth-Only Formula — 99th Percentile, Full Indexation, i.i.d.

Country	Growth*	Growth-Gap*	Difference
United States	90	89	−1
United Kingdom	87	85	−2
Austria	92	89	−3
Belgium	95	94	−1
France	84	80	−4
Germany	90	85	−5
Italy	87	86	−1
Netherlands	86	86	0
Sweden	96	93	−3
Canada	91	86	−5
Japan	75	69	−6
Greece	78	76	−2
Malta	90	87	−3
Portugal	84	85	1
Spain	71	70	−1

Note. The table reports the percentile of the non-indexed distribution corresponding to the 99th or 75th percentile of the indexed distribution, under full ($X = 1$) indexation with the optimal coefficient c^* and with optimal coefficients a^* and b^* from equations (A.9)–(A.10). Specification with i.i.d. shocks; 10-year horizon. The "Difference" column corresponds to the difference between columns Growth* and Growth-Gap*; negative values indicate larger reductions under the growth-gap optimal indexation. For the United States, growth-gap indexation using optimal coefficients a^* and b^* reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 89th percentile of the non-indexed distribution—equivalent to reducing an 11 percent tail probability to 1 percent. Source: Author's calculations.

Table A.6 Endogenous Interest Rate: Baseline vs. Endogenous Rate ($\phi = 0.03$), 99th Percentile, $c = 1$, 100% Indexed, 10-Year Horizon

Country	Baseline	Endo. ($\phi = 0.03$)	Diff.
United States	92	92	0
United Kingdom	93	93	0
Austria	94	94	0
Belgium	96	96	0
France	89	89	0
Germany	92	91	-1
Italy	89	88	-1
Netherlands	95	95	0
Sweden	97	97	0
Canada	93	93	0
Japan	78	76	-2
Greece	79	78	-1
Malta	91	91	0
Portugal	86	86	0
Spain	86	85	-1
Türkiye	98	98	0
Australia	94	94	0
South Africa	90	89	-1
Argentina	98	98	0
Brazil	87	87	0
Chile	96	96	0
Colombia	89	89	0
Costa Rica	86	86	0
Mexico	76	76	0
Peru	91	91	0
Israel	96	96	0
Egypt	95	95	0
India	82	82	0
Indonesia	87	86	-1
Korea	95	95	0
Cameroon	98	98	0

Note. "Baseline" reproduces the 100%-indexed column of Table 2. "Endo." uses $i_t = i_t^{\text{base}} + \phi \cdot \max(d_{t-1} - d_0, 0)$ with $\phi = 0.03$ (Laubach, 2009), applied to both indexed and non-indexed paths. "Diff." is Endo. minus Baseline. IID shocks, $c = 1$, $X = 1$, 10-year horizon. Source: Author's calculations.

Table A.7 Tail-Risk Reduction: Baseline vs. Stochastic k_t, $c = 1$, 100% Indexed, 10-Year Horizon

Country	99th percentile			75th percentile		
	Baseline	Stoch. k_t	Diff.	Baseline	Stoch. k_t	Diff.
United States	92	90	-2	65	64	-1
United Kingdom	93	90	-3	67	65	-2
Austria	94	93	-1	68	67	-1
Belgium	96	87	-9	70	63	-7
France	89	83	-6	64	60	-4
Germany	92	95	3	66	69	3
Italy	89	82	-7	64	59	-5
Netherlands	95	93	-2	69	67	-2
Sweden	97	96	-1	72	70	-2
Canada	93	87	-6	67	62	-5
Japan	78	80	2	58	59	1
Greece	79	86	7	57	59	2
Malta	91	92	1	66	66	0
Portugal	86	89	3	63	64	1
Spain	86	85	-1	62	61	-1
Türkiye	98	96	-2	73	65	-8
Australia	94	95	1	68	69	1
South Africa	90	83	-7	64	60	-4
Argentina	98	98	0	71	72	1
Brazil	87	84	-3	63	61	-2
Chile	96	97	1	71	71	0
Colombia	89	92	3	64	65	1
Costa Rica	86	73	-13	62	54	-8
Mexico	76	76	0	56	55	-1
Peru	91	92	1	66	66	0
Israel	96	95	-1	70	69	-1
Egypt	95	96	1	69	70	1
India	82	80	-2	60	59	-1
Indonesia	87	87	0	63	63	0
Korea	95	92	-3	71	65	-6
Cameroon	98	98	0	74	74	0

Note. "Baseline" repeats the 100%-indexed column of Table 2: $k_t = \hat{i}_t - \hat{g}_t$ is predetermined. "Stoch. k_t" uses $k_t = i_t - \hat{g}_t$, so interest-rate shocks feed directly into the indexed coupon. The numbers represent the percentile of the non-indexed distribution corresponding to the given percentile of the indexed distribution. IID shocks, $c = 1$, $X = 1$, 10-year horizon. Positive differences indicate the stochastic k_t assumption worsens the tail-risk protection from growth-indexed debt. Source: Author's calculations.

Table A.8 Optimal Indexation Coefficients: $c^\star$ vs. $c^{\star,k}$

Country	c^*	$c^{\star,k}$	Diff.
United States	1.4	1.4	0.0
United Kingdom	1.8	1.6	-0.2
Austria	1.5	1.4	-0.1
Belgium	1.5	1.4	-0.1
France	1.4	1.3	-0.2
Germany	1.4	1.6	0.2
Italy	1.2	1.0	-0.2
Netherlands	2.2	1.9	-0.3
Sweden	2.1	2.0	-0.1
Canada	1.3	1.3	0.0
Japan	1.2	1.2	0.0
Greece	1.1	0.8	-0.2
Malta	1.4	1.4	0.0
Portugal	1.2	1.1	-0.1
Spain	1.6	1.5	-0.1
Türkiye	1.1	0.6	-0.5
Australia	1.7	1.9	0.2
South Africa	1.8	1.5	-0.2
Argentina	0.9	1.0	0.1
Brazil	1.6	1.5	0.0
Chile	1.8	1.6	-0.2
Colombia	1.1	0.9	-0.3
Costa Rica	1.5	1.1	-0.4
Mexico	1.0	0.9	-0.1
Peru	1.7	1.8	0.0
Israel	1.7	1.7	0.0
Egypt	0.8	0.7	-0.1
India	1.2	1.2	0.0
Indonesia	1.6	1.6	0.0
Korea	1.6	1.1	-0.5
Cameroon	1.6	1.5	-0.1

Note. $c^\star$ is from equation (15) and $c^{\star,k}$ is from equation (A.16), both evaluated at the 2021 debt level. Source: Author's calculations.

Table A.9 Tail-Risk Reduction Under Stochastic k_t: $c = 1$ vs. $c = c^{\star,k}$, 100% Indexed, 10-Year Horizon

Country	99th percentile			75th percentile		
	$c = 1$	$c = c^{\star,k}$	Diff.	$c = 1$	$c = c^{\star,k}$	Diff.
United States	90	88	-2	64	62	-2
United Kingdom	90	86	-4	65	62	-3
Austria	93	91	-2	67	65	-2
Belgium	87	85	-2	63	60	-3
France	83	81	-2	60	59	-1
Germany	95	93	-2	69	67	-2
Italy	82	82	0	59	59	0
Netherlands	93	86	-7	67	61	-6
Sweden	96	94	-2	70	67	-3
Canada	87	85	-2	62	61	-1
Japan	80	78	-2	59	58	-1
Greece	86	85	-1	59	60	1
Malta	92	91	-1	66	64	-2
Portugal	89	89	0	64	63	-1
Spain	85	75	-10	61	56	-5
Türkiye	96	95	-1	65	67	2
Australia	95	93	-2	69	66	-3
South Africa	83	74	-9	60	55	-5
Argentina	98	98	0	72	72	0
Brazil	84	74	-10	61	55	-6
Chile	97	96	-1	71	70	-1
Colombia	92	92	0	65	65	0
Costa Rica	73	71	-2	54	53	-1
Mexico	76	76	0	55	56	1
Peru	92	86	-6	66	61	-5
Israel	95	93	-2	69	67	-2
Egypt	96	96	0	70	70	0
India	80	78	-2	59	58	-1
Indonesia	87	77	-10	63	57	-6
Korea	92	92	0	65	65	0
Cameroon	98	98	0	74	74	0

Note. Both columns use stochastic k_t with $k_t = i_t - c\hat{g}_t$ to ensure similar expected returns, $\mathbb{E}[\bar{i}_t] = i_t$, and debt paths between the indexed and non-indexed cases. Negative differences indicate larger reductions under $c^{\star,k}$. For the United States, indexation using the optimal coefficient $c^{\star,k}$ and assuming a stochastic k_t reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 88th percentile of the non-indexed distribution—equivalent to reducing a 12 percent tail probability to 1 percent. IID shocks, $X = 1$, 10-year horizon. Source: Authors calculations.

Table A.10 Fairly Priced Zero-Floor Indexed Coupon: Baseline vs. Fair Floor, 99th Percentile, $c = 1$, 100% Indexed, 10-Year Horizon

Country	Baseline	Fair floor	Diff.
United States	92	95	3
United Kingdom	93	97	4
Austria	94	97	3
Belgium	96	97	1
France	89	95	6
Germany	92	95	3
Italy	89	94	5
Netherlands	95	99	4
Sweden	97	98	1
Canada	93	99	6
Japan	78	98	20
Greece	79	98	19
Malta	91	97	6
Portugal	86	96	10
Spain	86	96	10
Türkiye	98	99	1
Australia	94	95	1
South Africa	90	90	0
Argentina	98	98	0
Brazil	87	90	3
Chile	96	98	2
Colombia	89	93	4
Costa Rica	86	94	8
Mexico	76	85	9
Peru	91	96	5
Israel	96	96	0
Egypt	95	96	1
India	82	85	3
Indonesia	87	93	6
Korea	95	99	4
Cameroon	98	98	0

Note. "Baseline" reproduces the 100%-indexed column of Table 2. "Fair floor" imposes $\bar{i}_t = \max(g_t + k_t^{\text{adj}}, 0)$ where k_t^{adj} is solved numerically each period to satisfy $\mathbb{E}[\max(g_t + k_t^{\text{adj}}, 0)] = \hat{i}_t$, ensuring the expected floored coupon equals the expected coupon on a non-indexed bond. Positive differences indicate that the fairly priced floor reduces tail-risk protection relative to the fully symmetric indexed bond. For the United States, indexation nder a fair floor assumption reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 95th percentile of the non-indexed distribution—equivalent to reducing a 5 percent tail probability to 1 percent. IID shocks, $c = 1$, $X = 1$, 10-year horizon. Source: Authorś calculations.

Table A.11 VAR(1) vs. i.i.d. Specification — $c = 1$ and $c = c^*$, 99th Percentile, 10-Year Horizon

Country	$c = 1$			$c = c^*$		
	IID	VAR	Diff.	IID	VAR	Diff.
Australia	94	90	−4	92	85	−7
Chile	96	92	−4	95	90	−5
Brazil	87	84	−3	79	68	−11
Indonesia	87	85	−2	77	74	−3
Spain	86	85	−1	71	65	−6
Netherlands	95	95	0	86	81	−5
Egypt	95	95	0	95	95	0
Belgium	96	97	+1	95	94	−1
Sweden	97	98	+1	96	97	+1
Türkiye	98	99	+1	97	99	+2
Argentina	98	99	+1	98	99	+1
Cameroon	98	99	+1	98	99	+1
Austria	94	96	+2	92	94	+2
Italy	89	91	+2	87	91	+4
South Africa	90	92	+2	76	79	+3
India	82	84	+2	80	82	+2
Israel	96	99	+3	93	99	+6
Korea	95	98	+3	91	94	+3
United States	92	96	+4	90	94	+4
United Kingdom	93	97	+4	87	92	+5
Japan	78	82	+4	75	78	+3
Portugal	86	90	+4	84	87	+3
Peru	91	95	+4	85	89	+4
Germany	92	97	+5	90	96	+6
Canada	93	98	+5	91	99	+8
Colombia	89	94	+5	88	93	+5
France	89	95	+6	84	89	+5
Costa Rica	86	92	+6	69	79	+10
Malta	91	98	+7	90	97	+7
Greece	79	88	+9	78	89	+11
Mexico	76	90	+14	77	89	+12

Note. The table reports the percentile of the non-indexed distribution corresponding to the 99th percentile of the indexed distribution at the 10-year horizon, under full ($X = 1$) indexation with indexation coefficient $c = 1$ or c^*, under the i.i.d. and VAR(1) specifications. The "Diff." column corresponds to the difference between columns IID and VAR; negative values indicate larger reductions under the VAR specification. For the United States, indexation using coefficient $c = 1$ reduces the 99th-percentile debt-to-GDP ratio after 10 years to a level corresponding to the 96th percentile of the non-indexed distribution—equivalent to reducing a 4 percent tail probability to 1 percent. Source: Author's calculations. Source: Author's calculations.



PUBLICATIONS

Growth-Indexed Bonds and Debt Distribution: Too Little, Too Costly?

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