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by Fabrizio Zampolli

Monetary and Economic Department

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Financial stability limits on fiscal space*

Fabrizio Zampolli
Bank for International Settlements

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Abstract

Conventional indicators of fiscal sustainability, such as the interest rate–growth differential that focus on long-term drivers do not always incorporate fluctuating financial conditions and risk. This paper proposes an analytical framework in which sovereign borrowing costs depend on the balance-sheet capacity of financial intermediaries, where financial amplification can generate an endogenously tighter debt limit even in the absence of fiscal fatigue or explicit default risk. Fiscal space becomes state-contingent: identical yield shocks compress fiscal space more strongly when the economy is closer to its debt limit. We examine four financial amplification mechanisms: the bank-sovereign nexus, "original sin redux", duration matching, and deleveraging in repo markets.

Keywords: fiscal sustainability; fiscal space; debt limit; financial stability; sovereign bond market; non-bank financial institutions.

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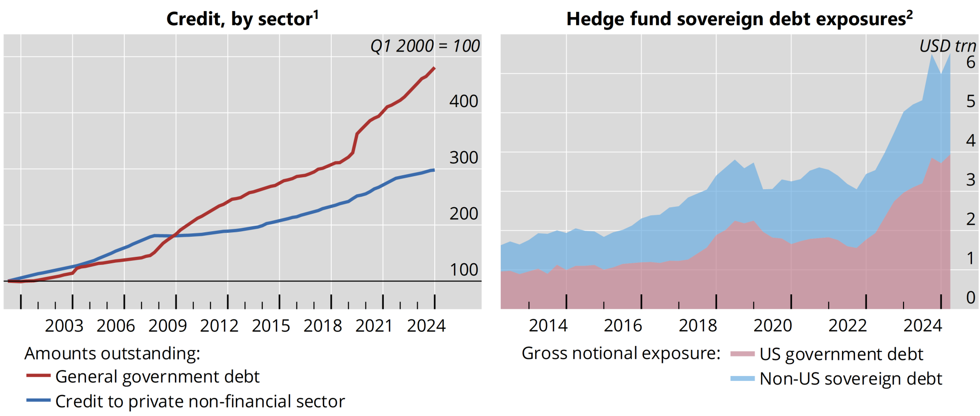
1 Introduction

Common indicators of fiscal sustainability such as the interest-growth differential ($r - g$), and analyses focused on long-term structural factors like demographics, productivity growth or household savings do not always take account of the role of financial intermediation and the procyclical behaviour of liquidity and risk. This paper introduces a framework that explicitly incorporates financial intermediation and market dynamics into the assessment of fiscal sustainability, where financial stability concerns emerge as an additional constraint that can significantly limit fiscal space and undermine debt stability, even when conventional fiscal sustainability indicators appeared favourable before the outbreak of financial stress.[1]

The role of procyclical liquidity and risk has become increasingly difficult to ignore, motivating the approach taken in this paper. Since the Great Financial Crisis (GFC), public debt has surged in many economies, accompanied by significant structural shifts in the global financial system (BIS (2025)). Lending to governments has grown much faster than financing to the private sector, while financial intermediation has shifted away from banks toward non-bank financial institutions (NBFIs) (Figure 1, left). At the same time, many NBFIs have expanded their global presence, holding diversified portfolios across currencies and emerging as major foreign lenders to sovereigns. Hedge funds, in particular, have experienced rapid growth, characterised by high leverage and heavy reliance on repo markets for funding, especially in the United States (Figure 1, right). These structural changes have diversified the investor base for sovereign debt but have also introduced new channels of financial instability. Unlike banks, NBFIs exhibit more heterogeneous liquidity needs and risk management strategies, which can amplify procyclical dynamics and exacerbate vulnerabilities in financial markets.

Our proposed framework for debt sustainability analysis (DSA) rests on four building blocks: (i) a debt accumulation equation; (ii) a fiscal rule,

[1] Public debt is considered sustainable "if there is a high probability that the government is able to honour its current and future obligations without resorting to unfeasible or undesirable policies" (Debrun et al. (2019)). This definition, used by institutions such as the IMF, encompasses not only formal default on the debt but also a variety of resolution scenarios, including exceptional fiscal adjustment, financial repression and high inflation.



[1] GDP-PPP weighted average across AU, CA, EA, GB, JP and US. Outstanding amounts of credit in local currency rebased to 100 at Q1 2000. General government debt at nominal value; it covers debt securities, loans and currency and deposits. Private non-financial sector includes non-financial corporations, households and non-profit institutions serving households. [2] Covers institutions operating in the United States with reporting requirements to the Securities and Exchange Commission. Gross notional exposure is the sum of the absolute value of long and short exposures, including via holdings of cash securities and through derivatives. US data include Treasuries and agency and government-sponsored entities bonds.

Sources: IMF; Office of Financial Research; national data; BIS.

Figure 1: The rise of public debt and non-bank finance.

which determines the primary fiscal balance; (iii) an interest rate schedule, which specifies the cost of borrowing for the government as a function of debt levels and the state of the financial system; and (iv) an equation that describes how the financial system evolves over time. While (i) and (ii) are standard in DSA analyses, the key innovation is that we derive (iii) and (iv) from the optimization problem of risk-constrained financial intermediaries, in line with the macro-financial literature on liquidity and risk (e.g. Brunnermeier and Pedersen (2009), Adrian and Shin (2010), Brunnermeier and Sannikov (2014), Shin (2010)). This allows us to explicitly link sovereign yields and measures of fiscal space to measurable financial stability or macro-prudential parameters. Specifically, we derive interest rate schedules – and their fiscal sustainability implications – based on four distinct financial amplification mechanisms:

- the *bank–sovereign nexus,* whereby rising sovereign yields erode banks' capital and feed back into higher funding costs for the government (e.g. Farhi and Tirole (2018), Gennaioli et al. (2014), Reinhart and Rogoff (2011));

- *the "original sin redux"*, in which foreign investors' exposures to local-currency sovereign bonds amplify exchange-rate and duration risk (e.g. Carstens and Shin (2019), Hofmann et al. (2020a, 2020b), Bertaut et al. (2023));

- *duration matching by long-term investors* such as pension funds and insurers, which can become procyclical when yields are low (e.g. Domanski et al. (2017));

- *deleveraging in repo markets*, where higher market volatility and weaker hedging correlations tighten hedge funds' risk constraints, reducing risk-bearing capacity and generating liquidity shortages that can spill over into FX-swaps markets (e.g. Aramonte et al. (2023), BIS (2025)).

Each mechanism shares similar qualitative implications, even though the underlying micro-channels differ. In all cases, sovereign borrowing costs depend on the balance-sheet or risk-bearing capacity of financial intermediaries so that shocks to sovereign yields are endogenously amplified. Four key results emerge. First, financial amplification can generate an endogenous debt limit. Crucially, this debt limit does not rest on fiscal fatigue, tax efficiency constraints, or strategic incentives to renege on debt commitments. Second, fiscal space is shown to be positively related to financial amplification parameters such as, for instance, financial intermediaries' capital, looser Value-at-Risk (VaR) constraints, capital market depth, or market volatility. Third, financial amplification makes fiscal space state-contingent. Identical shocks to sovereign yields reduce fiscal space more sharply when initial fiscal space is smaller, especially when the economy is already near its debt limit. Fourth, the region of stability is smaller: local stability requires a stronger fiscal response, as adverse shocks not only increase debt but also erode financial intermediaries' capital, thus raising marginal borrowing costs more sharply. As a result, conventional debt sustainability indicators such as the growth-adjusted interest rate $r - g$, are not sufficient statistics for assessing fiscal sustainability because the financial system's capacity to intermediate public debt may quickly and sharply deteriorate, in line with empirical evidence (e.g. Mauro and Zhou (2021)).[2]

While these qualitative implications are similar across mechanisms,

[2] Mauro and Zhou (2021) show that average $r - g$ is a poor predictor of debt crises. See also Lian et al. (2020) who find that the probability of the differential remaining negative is smaller and the size of the reversal larger, the higher the debt and the larger the share of debt denominated in foreign currency.

their quantitative effects can differ significantly. That said, the objective of this paper is not to build a fully realistic DSA model for quantification but to present these channels and their theoretical implications as transparently as possible.

Relationship with the literature. Our approach departs from traditional analyses of fiscal sustainability that evaluate future primary surpluses using a constant or exogenous discount factor. A recent example of this approach is Blanchard (2019), who argues that when the average interest rate on public debt remains below the growth rate of the economy ($r < g$), the welfare costs of public debt are small and governments can sustain higher debt levels. Blanchard (2019) acknowledges that risk premia could in principle invalidate this conclusion but downplays their empirical relevance and does not model how they might vary with economic or financial conditions. In more recent work, Auclert et al. (2025) endogenise the real interest rate through the equilibrium between asset supply and asset demand. In their framework, the interest rate reflects long-term structural forces such as demographics, productivity growth, and households' saving behaviour. While this approach can explain movements in the equilibrium real interest rate over the long run, it abstracts from risk and from the role of financial intermediation in shaping discount factors over shorter horizons.

In contrast with these approaches, several analyses incorporate state-contingent risk. Ghosh et al. (2013) and Lorenzoni and Werning (2019), among others, show how the probability of default escalates with rising debt, reflecting "fiscal fatigue" – the decreasing capacity of fiscal policy to raise sufficient fiscal surpluses to cover growing debt servicing costs. Treating public debt as a risky asset in a standard asset pricing model, Jiang et al. (2022, 2023, 2024) show how the covariance of fiscal surpluses with aggregate risk raises the appropriate discount rate and thereby tightens fiscal space. However, these analyses still abstract from the market mechanisms that drive liquidity conditions. Our paper contributes to this literature by explicitly incorporating financial intermediation into the analysis of fiscal sustainability, thus establishing a bridge with the macro-financial literature on risk and procyclical liquidity (e.g. Brunnermeier and Pedersen (2009), Adrian and Shin (2010), Brunnermeier and Sannikov (2014), Shin (2010)). Moreover, our framework allows for debt limits to arise purely from financial intermediaries' constraints as opposed to fiscal fatigue (e.g. Ghosh et al. (2013) and Lorenzoni and Werning (2019)), Laffer curve arguments (e.g. Bi (2012), Trabandt and Uhlig (2011)) or strategic incentives to renege on debt commitments (e.g. Arellano (2008)).

Our analysis is also related in spirit to the literature on self-fulfilling liquidity crises (e.g. Calvo (1988), Cole and Kehoe (2000), Aguiar et al. (2015), Corsetti and Dedola (2016), Lorenzoni and Werning (2019)), but departs from it in a fundamental respect. In the self-fulfilling crises literature, financial fragility arises from a coordination problem among unconstrained investors: beliefs may shift even if fundamentals do not change. The policy challenge in this context is to rule out the possibility of a bad equilibrium, for instance through debt containment, maturity management or central bank backstop. By contrast, our framework focuses on the capacity to absorb public debt, even when expectations are well anchored. Here, the policy challenge is how to enhance the resilience of liquidity, which is a goal more aligned with macro-prudential policies and structural measures to deepen financial markets. Finally, similar to the recent work by Lorenzoni and Werning (2019), our approach can, in principle, capture both the gradual erosion of lending capacity and sudden episodes of financial stress.

The remainder of this paper is organised as follows. Section 2 lays out a bare-bones analytical framework that can be used to examine the interaction between fiscal sustainability and financial market conditions. Section 3 then delves into the description of the four key amplification channels and their implications for fiscal sustainability. Finally, Section 4 concludes with directions for future research.

2 A general framework

Our framework for analysing how financial stability factors affect public debt sustainability comprises four building blocks.

The first is the *debt dynamic equation*, an accounting identity describing how the debt to GDP ratio b_{t+1} evolves over time:

$$b_{t+1} = \frac{1 + r_t}{1 + g_t} b_t - s_{t+1} \tag{1}$$

where r_t is the effective interest rate, g_t the GDP growth rate and s_t the primary fiscal surplus (as a share of GDP).[3] Here, the term $\frac{1+r_t}{1+g_t}b_t$ is the so-called "snowball effect", which tends to boost the debt ratio when $r_t > g_t$ unless it is offset by a sufficiently large primary fiscal surplus.[4]

The second block describes how *fiscal policy* responds to the debt-to-GDP ratio:

$$s_{t+1} = \phi(b_t) \tag{2}$$

Here $\phi(b_t)$ is increasing in debt and may also exhibit concavity ($\phi^{'}(\cdot) > 0$, $\phi^{''}(\cdot) \leq 0$). The concavity of the fiscal reaction function could capture "fiscal fatigue" – the empirically observed tendency for the increases in the primary balance to diminish at higher debt levels. However, this feature is not strictly essential to our framework.[5]

The third block is the *interest rate schedule*, which captures how financial conditions as summarised by the interest rate r_t depends on the debt level and the state of the financial system x_t:

$$\frac{1+r_t}{1+r_t^*} = f(b_t, x_t) \tag{3}$$

This equation defines a premium over the risk-free rate r_t^*, where $f(\cdot)$ captures a potentially non-linear dependence on the debt level and a shifter or interaction term x_t that captures the state of the financial system.[6] The premium is assumed to be increasing in the debt level ($f_b'(\cdot) > 0$) and may also exhibit convexity ($f_{bb}'(\cdot) \geq 0$). Shin (2010, Section 3.1) shows that such a relationship is a general feature emerging from market clearing in models of procyclical leverage and risk driven by Value-at-Risk constraints

[3] As an effective interest rate, r_t may reflect various factors, including the maturity and currency composition of the debt.

[4] Iterating forward (1) and setting $\delta_t \equiv (1+r_t)/(1+g_t)$ give the present value form of the government's intertemporal budget constraint:

$$b_t = \sum_{j=1}^{\infty}\left(\prod_{k=0}^{j-1}\delta_{t+k}\right)^{-1} s_{t+j}$$

where it is assumed that the transversality condition holds, $\lim_{n\to\infty}\prod_{k=0}^{n-1}\delta_{t+k}b_t = 0$. In this form, it is clear that δ_t is the time-varying discount rate applied to future fiscal primary balances.

[5] Fiscal fatigue can arise from economic constraints, such as the diminishing returns of taxation (Laffer curve effects) or political constraints, such as reduced public support for austerity measures. Fiscal fatigue is a feature that leads to the existence of a debt limit in some analytical frameworks (e.g. Ghosh et al. (2013)).

[6] The risk-free rate r_t^* can be interpreted as the overnight interest rate controlled by the central bank or the short-term funding rate faced by financial institutions engaged in intermediating sovereign debt securities.

on financial intermediaries' capital.[7]

The final building block describes how the *state of the financial system* x_t evolves over time:

$$x_{t+1} = g(x_t, b_t, r_t)$$

Here x_t can be either a scalar or a vector of variables. The future state of the financial system may depend – beside its own current state – on the debt level and the interest rate. In the analysis of various financial amplification mechanisms in the next section, the interest rate schedule (3) will generally take the form of

$$r_t = r^* + ab_t + \gamma x_t, \tag{4}$$

where x_t includes either the capital position of financial intermediaries or market volatility and responds to change in the interest rate, among other factors.

3 Channels of financial amplification

This section presents four distinct channels of financial amplification: (i) the bank-sovereign nexus; (ii) the "original sin redux"; (iii) duration matching by long-term investors; and (iv) deleveraging in repo markets. By examining each channel separately, the discussion aims to provide a clear understanding of their mechanisms and implications. All four mechanisms share the feature that risk management by financial institutions plays a key role.

3.1 The bank-sovereign nexus

The banking sector and the sovereign are deeply interdependent, with the weakness of one spilling over to the other (Borio et al. (2023)).[8] In one direction, weaker fiscal conditions weaken banks through several channels:

[7] In standard DSA models, expressions such as (3) can accommodate explicit default, as explored in studies like Ghosh et al. (2013) and Lorenzoni and Werning (2019). In this case, (3) is written as a non-arbitrage condition, whereby investors (assumed to be risk-neutral, atomistic and unconstrained) demand compensation for the expected loss associated with default. Additionally, by making the probability of default dependent on investors' expectations, this formulation also offers an avenue for analysing belief-driven liquidity crises, where both good and bad equilibria may coexist for the same underlying fundamentals (e.g. Calvo (1988)).

[8] Borio et al. (2023) review the relevant channels and the empirical evidence.

first, higher sovereign yields lead to direct losses for banks that hold a substantial share of their assets in government securities; second, higher yields can also tighten banks' funding conditions as their perceived riskiness increases; and, third, banks are indirectly exposed to any broader economic fallout caused by fiscal stress through losses on private loans and tighter broad financial conditions.

In the other direction, weaker banks increase the cost of borrowing for the sovereign. One channel is by raising the probability of a financial crisis and the associated expected cost of government support. These costs encompass both the direct costs of bailouts and the indirect costs arising from the deterioration of fiscal accounts due to the crisis-induced recession and the subsequent fiscal response (e.g. Borio et al. (2020)). Another complementary channel is through tighter balance sheets' constraints. Weaker balance sheets (e.g. as a result of an increase in yields) can limit financial intermediaries' capacity to absorb further public debt increases, thereby putting further upward pressure on sovereign borrowing costs.

In this section, we present an analytical framework to explore the amplification mechanism of the bank-sovereign nexus, incorporating some of the channels highlighted above. For simplicity, we assume a representative bank that exclusively holds long-term nominal bonds and finances its operations through deposits.[9] In our example, these bonds are risk-free if held to maturity, but the bank remains exposed to interest rate risk. The bank is assumed to operate under a VaR constraint, even though banks are generally not required to mark to market their government bond holdings unless these holdings are classified under the trading book. While these losses are not visible in accounting statements, unrealised losses can still reduce the true value of bank equity and may attract scrutiny from depositors and other market participants. Moreover, supervisors regularly conduct stress tests on banks' bond portfolios. For these reasons, even without mark-to-market accounting, losses could affect collateral values and funding costs, potentially affecting banks' demand for bonds. Another justification for using VaR constraints is that the model can also describe the behaviour of mutual funds. A similar amplification mechanism applies to bond mutual

[9] At the cost of complicating the algebra, the model can be made more realistic with the inclusion of loans to the private sector and an endogenous response of economic growth to these loans.

funds, which, despite being low-leverage investors, remain vulnerable to redemption risk.

3.1.1 Representative bank

At date t, the bank holds h_t units of the long-term bond (with yield r_t, price $q_t = Q(r_t)$ and coupon c_t), finances itself with deposits d_t at gross rate R_t^f and equity e_t:

$$q_t h_t = d_t + e_t$$

The bank's expected profit between periods is given by:

$$E_t \pi_{t+1} = E_t \left(\frac{c_{t+1} + q_{t+1} - q_t}{q_t} - R_t^f \right) q_t h_t - r_t^f e_t \approx \xi_t q_t h_t \tag{5}$$

where ξ_t is the expected excess return on the bond at time t, and r_t^f is the cost of equity. The term $r_t^f e_t$ is independent of the choice h_t.

The bank is facing a Value-at-Risk (VaR) constraint that limits the mark-to-market losses that it can incur when the bond yield changes. Even if it is not required to mark to market losses, the bank wants to reduce the adverse consequences of seeing the true value of its equity fall. Alternatively, we can interpret the model as that of a bank holding bonds on the trading book.

Assuming for simplicity that the bank can take only long positions in bonds (so that $h_t \geq 0$) and given the duration approximation $\Delta q_{t+1} \approx -D_t q_t \Delta r_{t+1}$, this VaR constraint can be written as:

$$h_t \leq \frac{e_t}{\alpha \sigma_t D_t q_t} \tag{6}$$

The constraint (6) caps bond holdings to ensure that potential losses from interest rate risk – which are increasing in volatility σ_t and duration D_t – do not breach the bank's VaR constraint. The parameter α captures how tight the risk constraint is.[10]

The bank maximises its expected profit (5) subject to (6). As long as the expected excess return $\xi_t > 0$ the VaR constraint is binding, yielding

[10] The VaR constraint (6) originates from a probabilistic statement of the form $\Pr(Loss_t > e_t) \leq 1 - p$, where the probability p is the chosen confidence level (e.g. 99%). Assuming changes in bond prices are approximately normal, the worst-case loss at confidence level p can be written as $\text{VaR}_t \simeq \alpha \sigma_t D_t q_t h_t$, where α is the quantile of the return distribution corresponding to p. See e.g. Shin (2010) and references therein.

the demand for bonds by banks:

$$h_t = \frac{e_t}{\alpha \sigma_t D_t q_t} \tag{7}$$

Longer duration, higher perceived market volatility, or tighter capital limits reduce the portfolio size.[11] Equivalently, the bank's leverage satisfies $h_t q_t / e_t = (\alpha \sigma_t D_t)^{-1}$.

Bank equity changes with the realised mark-to-market profits or losses π_{t+1} minus any dividend payment plus any additional equity injection ι_t:

$$e_{t+1} = e_t + \pi_{t+1} - \text{div}_{t+1} + \iota_{t+1}$$

Substituting the realised profit or loss from changes in yields and ignoring for simplicity dividends and new issuance, equity evolves according to:

$$e_{t+1} = e_t + (r_t^c - D_t \Delta r_{t+1}) q_t h_t$$

where $r_t^c = c_{t+1}/q_t - r_t^f$ is the carry return. By setting $r_t^c \approx 0$ and replacing the bond demands under the VaR constraint, this expression can be rewritten as:

$$e_{t+1} = \left(1 - \frac{1}{\alpha \sigma_t} \Delta r_{t+1}\right) e_t \tag{8}$$

3.1.2 Market clearing and pricing

We close the model by assuming that outside investors (e.g. pension funds, insurance companies) have a downward-sloping demand for sovereign bonds which, for simplicity, is expressed as a linear function of the deviation of the yield from a benchmark level r:

$$x^O(r_t) = \bar{x}^O + \beta^O (r_t - r) \tag{9}$$

where $\bar{x}^O$ is the component of demand that does not depend on interest rate and $\beta^O > 0$ measures how far yields need to change to induce outside investors to absorb an extra unit of debt. Denoting the total stock of government bonds with b_t and taking a first-order approximation of the market clearing condition – i.e. $b_t = h_t + x^O(r_t)$ – yields the reduced-form

[11] In what follows we only focus on the case where there is a positive carry.

interest rate curve:[12]

$$r_t = r^* + ab_t - \gamma e_t \tag{10}$$

where the intercept r^* absorbs all the constant terms and can be interpreted as the baseline rate and

$$a \equiv \beta^{-1} \equiv \left(\beta^O + \frac{e}{\alpha\sigma q}\right)^{-1} \qquad \gamma \equiv (\beta\alpha\sigma D q)^{-1}$$

The slope coefficient a in (10) represents the inverse of market depth, β. This coefficient is influenced not only by the sensitivity of outside investors' demand to yield changes β^O but also by the capacity of banks to absorb extra debt. This capacity is captured by the term $\frac{e}{\alpha\sigma q}$, which reflects a partially stabilising effect. Namely, higher yields reduce bond prices, which allows a given stock of intermediary capital to absorb a larger volume of debt, thereby increasing market depth and attenuating the marginal impact of debt on yields.[13]

3.1.3 Financial amplification

To illustrate the amplification mechanism, consider now an exogenous positive shock to the bond yield, denoted as $\varepsilon_{t+1} \equiv \Delta r_{t+1} > 0$. From (8) and given the binding VaR constraint (7), the shock results in a decline in bank

[12] Equation (10) is obtained as a first-order approximation of the market clearing condition, which is implicit in r_t because $q_t = Q(r_t)$. Let

$$F(r_t, b_t, e_t) = \frac{e_t}{\alpha\sigma_t D_t Q(r_t)} + \bar{x}^O + \beta^O(r_t - r) - b_t = 0$$

Applying the implicit function theorem around the reference point (r, b, e) and evaluating σ_t and D_t at their local reference values (σ, D), gives

$$r_t - r \approx -\frac{F_b}{F_r}(b_t - b) - \frac{F_e}{F_r}(e_t - e)$$

with

$$F_b = -1, \quad F_e = (\alpha\sigma D q)^{-1}, \quad F_r = \beta^O + \frac{e}{\alpha\sigma D}\left(\frac{d}{dr}\frac{1}{Q(r_t)}\right)_{r_t = r}$$

Using $Q'_r(r) = -Dq$, we obtain $\left(\frac{d}{dr_t}\frac{1}{Q(r_r)}\right)_{r_t=r} = -\frac{Q'_r(r)}{q^2} = \frac{D}{q}$. Hence, $F_r = \beta^O + \frac{e}{\alpha\sigma q}$. Here, duration is evaluated at the reference yield and treated as a constant, i.e. $D_t \approx D$. This is consistent with a first-order linearisation of the bond price function: variation in duration as yields change reflects convexity and are second order.

[13] In equation (10), r_t is an effective interest rate on government debt and hence the coefficients a and γ should be interpreted as effective sensitivities. In numerical exercises, they should be calibrated to deliver plausible debt and equity elasticities of financing costs rather than literal pass-through from current market yields to the average cost on the outstanding stock of debt.

equity that can be expressed as:

$$\Delta e_{t+1} = -\frac{e_t}{\alpha\sigma}\varepsilon_{t+1}$$

With slow-moving variables or in a steady state, the term

$$\Gamma \equiv \frac{e}{\beta\alpha^2\sigma^2 Dq} \tag{11}$$

captures the first-round amplification of yields movement associated with the bank-sovereign nexus in the impact period. As the increase in yield causes equity to fall further, there will be an additional round of effects on the yield within the impact period. The total within-the-period amplification effect can therefore be approximated by the geometric series sum: $\Delta r_{t+1} = (1 + \Gamma + \Gamma^2 + ...)\,\varepsilon_{t+1} = \frac{1}{1-\Gamma}\varepsilon_{t+1}$, with $\Gamma < 1$.[14] This amplification is proportional to the level of bank equity and decreases with market depth. At the same time, amplification is stronger with shallower capital markets, looser risk constraints, lower volatility and shorter duration, because – as noted above – these factors tend to increase the exposure of banks to sovereign bonds.

3.1.4 Implications for fiscal sustainability

To study the implications of the bank-sovereign nexus amplification channel for fiscal sustainability, we can combine the interest rate schedule (10) with the debt dynamic equation (1) to obtain:

$$b_{t+1} = (1 + \delta + ab_t - \gamma e_t)b_t - s(b_t)$$

where we use the approximation $(1+x)\,/\,(1+y) \simeq 1 + x - y$ and set $\delta \equiv r^* - g$.

Additionally, we assume that equity reverts gradually toward a target $\bar{e}$ at rate $\rho_e \in (0, 1]$:

$$e_{t+1} = (1 - \rho_e)e_t + \rho_e\bar{e} - \eta e_t\Delta r_{t+1}, \quad \eta \equiv (\alpha\sigma)^{-1}$$

[14] On impact, public debt is predetermined so that the contemporaneous effect of the shock operates only through bank equity. Formally, the impact is found by solving the fixed-point equation for Δr_{t+1}. The impact change in yields is $\Delta r_{t+1} = \varepsilon_{t+1} - \gamma_t\Delta e_{t+1}$, while $\Delta e_{t+1} = -\eta_t e_t\Delta r_{t+1}$. Substituting gives $\Delta r_{t+1} = \varepsilon_{t+1} + \gamma_t\eta_t e_t\Delta r_{t+1}$. Solving this expression and noting that $\Gamma = \gamma_t\eta_t$ give $\Delta r_{t+1} = (1-\Gamma)^{-1}$ provided $\Gamma < 1$. To compute the cumulative multiplier over multiple periods, one has to keep track of the dynamics of public debt and equity. See below.

If the bank incurs a loss and its capital drops below its target level, it will be gradually recapitalised, for instance through retained earnings. Conversely, if the bank holds excess capital, it will progressively distribute dividends to its shareholders until it returns to its target level.

In steady state, $\Delta r_{t+1} = 0$, equity is at its target level $e = \bar{e}$, and the interest rate is given by $r = r^* + ab - \gamma\bar{e}$. Thus, the steady-state debt level satisfies the following condition:

$$s(b) = \underbrace{(\delta - \gamma\bar{e})b + ab^2}_{\equiv C(b)} \tag{12}$$

That is, the primary balance $s(b)$ must equal total interest payments $C(b)$. Since $a > 0$, this cost is increasing and convex in the debt level.

Proposition 1: Steady state and local stability in the bank-sovereign nexus model. *Assume the fiscal reaction function is linear $s(b) = \hat{s} + \phi b$ with $\hat{s} < 0$, and that the interest rate schedule implies a convex interest cost term in debt (i.e. $a > 0$). If the discriminant condition holds, then there exists two steady state equilibria $0 < b^s < \bar{b}$ corresponding to the roots of the quadratic equation $ab^2 + (\delta - \gamma\bar{e} - \phi)\, b - \hat{s} = 0$.*[15] *The upper steady state $\bar{b}$ is unstable and can be interpreted as an endogenous debt limit. The lower steady state b^s is locally stable if it satisfies the following key conditions (derived in Appendix A):*[16]

$$\phi > R(b^s) \equiv \underbrace{\delta - \gamma\bar{e} + 2ab^s}_{\equiv C_b'(b^s)} + \underbrace{\frac{\zeta a\bar{e} \cdot ab^s - \rho_e}{1 - \zeta a\bar{e} - \rho_e}}_{\text{financial fragility premium}}, \qquad \zeta \equiv \frac{1}{\alpha^2\sigma^2 Dq} \tag{13}$$

$$\zeta a\bar{e} < 1 - \rho_e \tag{14}$$

Condition (13) requires the fiscal response ϕ to be sufficiently strong to offset the marginal cost of debt. This marginal cost has two components.

[15] The two roots of the quadratic equation are:

$$b = \frac{1}{2a}\left(-(\delta - \gamma\bar{e} - \phi) \pm \sqrt{\Delta}\right) \qquad \Delta \equiv (\delta - \gamma\bar{e} - \phi)^2 + 4a\hat{s}$$

A positive discriminant, $\Delta > 0$, ensures the existence of the roots, while $\hat{s} < 0$ and $\phi > \delta - \gamma\bar{e}$ are necessary for both roots to be strictly positive, i.e. $0 < b^s < \bar{b}$. For both roots to be positive, their sum should be positive, which implies $\frac{-(\delta-\gamma\bar{e}-\phi)}{a} > 0$. For $a > 0$, this implies $\phi > \delta - \gamma\bar{e}$. For b^s to be strictly positive, $(\phi - \delta + \gamma\bar{e}) > \sqrt{(\delta - \gamma\bar{e} - \phi)^2 + 4a\hat{s}}$. Squaring and simplifying yields $4a\hat{s} < 0$. Since $a > 0$, $\hat{s} < 0$.

[16] A technical further upper bound condition on ϕ is needed for local stability. This is reported in Appendix A.

The first is the marginal cost that would prevail in the absence of changes in bank equity. It only depends on market thinness a. The second component is a premium reflecting financial fragility. It arises from the bank-sovereign amplification mechanism – the feedback on yields caused by changes in bank equity. This amplification depends crucially on the speed of recapitalisation after a shock ρ_e.[17] When recapitalisation is gradual – i.e. $\rho_e < \zeta a\bar{e} \cdot ab^s$ – the premium is positive and hence narrows the region of stability. On the contrary, when recapitalisation is sufficiently rapid so that $\rho_e > \zeta a\bar{e} \cdot ab^s$, the feedback loop is dampened and the required fiscal response is reduced. In this case, financial intermediation absorbs rather than propagates shocks. Finally, condition (14) is a financial instability boundary: it requires that the endogenous yield-equity feedback is weaker than the financial system's ability to absorb losses over time, otherwise the lower steady state would cease to be locally stable and small shocks generate explosive dynamics.

Some parameters have an unambiguous effect on the stability threshold $R(b^s)$. Greater market thinness a and stronger amplification parameters ζ increase the required fiscal response ϕ, as they amplify the marginal cost of debt and intensify feedback effects. Conversely, faster recapitalisation (higher ρ_e) reduces dynamic amplification, thereby expanding the region of stability. Other parameters, however, influence stability through offsetting channels. For example, higher interest-growth differential δ raises the marginal borrowing cost directly but simultaneously reduces the steady-state debt level, weakening amplification. Similarly, stronger bank equity $\bar{e}$ lowers spreads directly but also increases bank sovereign exposure, intensifying feedback effects. As a result, the overall impact of these variables on stability depends on which channel dominates.

The following proposition ties fiscal space to the health of the financial system, among other factors.

Proposition 2: Steady-state fiscal space in the bank-sovereign nexus model. *The distance between the two steady states can be interpreted as the fiscal space in the absence of shocks:*

$$FS = \bar{b} - b^s = \frac{\sqrt{\Delta}}{a}, \qquad \Delta \equiv (\delta - \gamma\bar{e} - \phi)^2 + 4a\hat{s} \tag{15}$$

[17]Market thinness is squared (a^2) because it involves a price effect ab^s and the equity feedback $\zeta a\bar{e}$.

In the economically relevant region $\phi > \delta - \gamma \bar{e}$, steady-state fiscal space is larger when the risk-free growth-adjusted interest rate δ is lower, the fiscal response ϕ is stronger and sovereign debt markets are deeper, as captured by a lower value of a. Fiscal space is also increasing in bank equity $\bar{e}$ and decreasing in the tightness of the VaR constraint α, market volatility σ and bond duration D.[18]

Note that bank equity impacts on fiscal space both directly through the term $-\gamma \bar{e}$ and indirectly by changing market depth through a and γ (see equation (10)). Hence, bank equity expands fiscal space for two reasons: better capitalised banks compress sovereign spreads directly and can absorb more debt without generating the same increase in borrowing costs. By contrast, a tighter VaR constraint, higher volatility or longer duration weaken banks' risk-bearing capacity and limits their willingness to hold sovereign bonds.

The steady-state measure of fiscal space derived above is an ex-ante concept. In practice, however, the fiscal space available to a government after a financial shock may differ substantially from its steady-state level. To assess whether current fiscal space provides an adequate buffer, it is essential to determine how much fiscal space could be lost following a shock.

Consider a positive exogenous innovation to the sovereign yield, $\varepsilon_{t+1} > 0$. As shown in Section 3.1.3 and Appendix A, financial amplification generates a change in the yield on impact equal to $(1-\Gamma)^{-1} \equiv (1-\zeta a \bar{e})^{-1} \cdot \varepsilon_{t+1}$ and a corresponding drop in equity of $-\eta \bar{e} (1-\zeta a \bar{e})^{-1} \cdot \varepsilon_{t+1}$. To undertand how this equity loss impacts on fiscal space, consider a first-order approximation of fiscal space around the steady state:

$$FS_{t+h} - FS(\bar{e}) \approx FS'_e(\bar{e}) \cdot (e_{t+h} - \bar{e}), \qquad h \geq 1$$

where

$$FS'_e(\bar{e}) = \frac{1}{a(\bar{e})^3 FS(\bar{e})} \left\{ \underbrace{a(\bar{e})\,\psi(\bar{e})\,\psi'_e}_{\text{spread-compression effect}} \quad \underbrace{-a'_e \left[\psi(\bar{e})^2 + 2a(\bar{e})\,\hat{s}\right]}_{\text{market-depth effect}} \right\} > 0$$

[18] A comparative statics analysis of the impact of α, σ and D on steady-state fiscal space is straightforward, as all these parameters influence fiscal space in a monotonic manner. However, determining the sign of the derivative of fiscal space with respect to equity is less straightforward (see Appendix A).

where $\psi(\bar{e}) \equiv \delta - \phi - \gamma(\bar{e})\bar{e}$. The derivative is positive in the economically relevant region, $\phi > \delta - \gamma\bar{e}$ (as shown in Appendix A). With this, we can state the following proposition.

Proposition 3: State-contingent fiscal space in the bank-sovereign nexus model. *Suppose the economy is initially at the stable steady state. Let $\varepsilon_{t+1} > 0$ denote a positive exogenous shock to the sovereign yield. Then the impact response of fiscal space is approximately*

$$FS_{t+1} - FS\left(\bar{e}\right) \approx -FS_e'\left(\bar{e}\right) \cdot \gamma^{-1} \cdot \underbrace{\frac{\zeta a \bar{e}}{1 - \zeta a \bar{e}}}_{\text{financial amplification}} \cdot \varepsilon_{t+1} < 0.$$

Hence, over the economically relevant region $\phi > \delta - \gamma\bar{e}$, a positive yield shock reduces fiscal space. The magnitude of this reduction depends on the strength of financial amplification, captured by $\zeta a \bar{e}$, and is therefore larger when the yield-equity feedback is stronger, for example when markets are thinner or risk constraints are looser. Moreover, for a given shock, the contraction in fiscal space tends to be larger when steady-state fiscal space is smaller.

More generally, the response of fiscal space over a longer horizon can be expressed as:

$$FS_{t+h} - FS\left(\bar{e}\right) \approx FS_e'\left(\bar{e}\right) \cdot e_2' J^{h-1} e_2 \cdot \frac{-\eta\bar{e}}{1 - \zeta a \bar{e}} \cdot \varepsilon_{t+1}, \qquad h \geq 1.$$

where J is the Jacobian matrix of the linearised bank-sovereign nexus model, which describes the deviations of public debt and bank equity, (b_{t+h}, e_{t+h}), from their respective steady states (see Appendix A). Thus, the persistence of the contraction in fiscal space inherits the persistence of these two variables.

A few remarks are in order. The bank-sovereign nexus framework challenges the sufficiency of the growth–interest rate differential $r - g$ (or δ in our framework) as a measure of fiscal sustainability. In standard sustainability analyses, $r - g$ summarises the snowball effect and is treated as exogenous to sovereign debt and financial conditions – that is, the borrowing rate does not depend on the level of public debt or on intermediary balance sheets – even though it may be determined by broader macroeconomic factors. In contrast, our framework endogenises the borrowing rate by linking it to financial conditions.

This also sets it apart from the liquidity crises literature. In models of self-fulfilling crises, instability arises from shifts in beliefs that trigger rollover failures, even without changes in fundamentals. By comparison, the instability in our framework is structural rather than coordination-driven. It reflects endogenous constraints on intermediary balance sheets that tighten as debt increases. The resulting debt limit is therefore not the product of pessimistic expectations, but of deteriorating financial intermediation capacity.

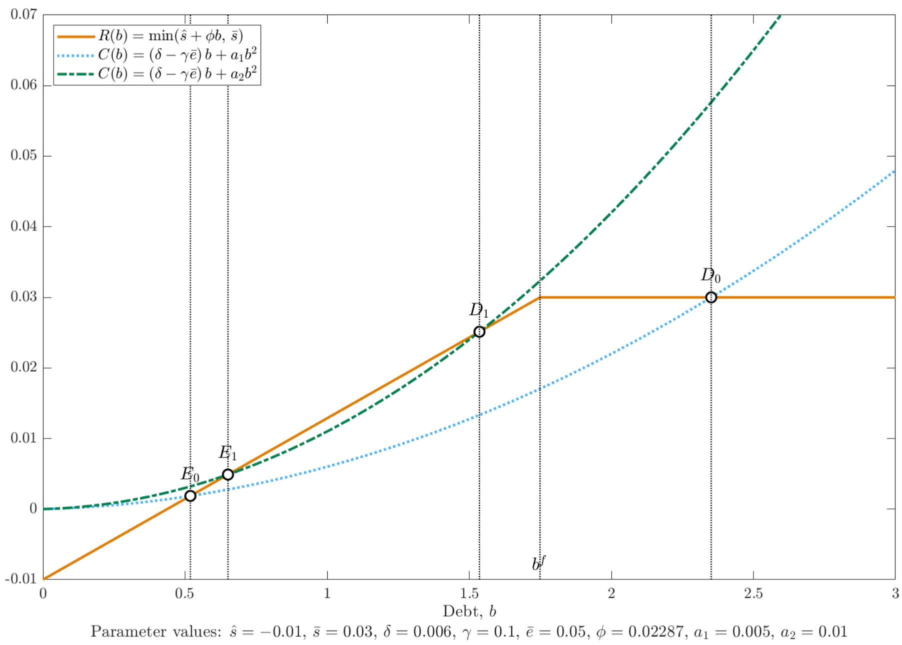


Figure 2

The debt limit arising in our framework also differs from other approaches in the literature, which attribute debt limits to fiscal fatigue (e.g., Ghosh et al. (2013)), Laffer curve constraints (e.g. Trabandt and Uhlig (2011)) or strategic default incentives (e.g., Arellano (2008)). Instead, it is shaped by the structural characteristics of the financial system. This distinction is illustrated in Figure 2, where the fiscal reaction function is assumed to have a piecewise form: initially linear and then flat, reflecting either fiscal fatigue or the fiscal limits implied by the tax Laffer curve. Two sets of equilibria are presented, differing only in the parameter value of a. For a low value of $a = a_1$, the stable debt level is E_0 and the debt limit is D_0, with the gap between them representing the fiscal space available in the steady state. Conversely, for a high value of $a = a_2$, the debt limit falls from D_0 to D_1, while the stable debt level rises from E_0 to E_1, resulting in a narrower fiscal space. Crucially, the debt limit is now determined by the convex borrowing cost rather than limit of fiscal capacity.

3.2 The "original sin redux"

"Original sin redux" is a term coined by Carstens and Shin (2019) to describe how vulnerabilities in emerging market economies (EMEs) have evolved rather than disappeared. The "original sin" idea referred to EMEs' inability to borrow from foreigners in their own currencies due to weak institutions and policy credibility, leaving them no other option than to issue external debt in foreign currency. Yet this left them exposed to significant balance sheet losses whenever their currencies depreciated. In recent decades, the development of local-currency bond markets and the adoption of stronger policy frameworks have enabled many EMEs to borrow in domestic currencies. However, while this shift has enhanced their resilience, EMEs remain vulnerable to changes in global financial conditions.

In the "redux" version, the risk does not disappear but migrates from borrower to lender. When foreign investors hold local-currency bonds, exchange rate movements generate valuation losses in their hard-currency terms. These losses, in turn, can trigger portfolio outflows, raise yields, and amplify exchange-rate depreciations, re-creating the same external fragility through a different channel. Hofmann, Shim and Shin (2020) test this mechanism, showing that EM local-currency yields remain highly sensitive to global financial conditions and US dollar fluctuations. Later work highlights how duration risk and redemption pressures among investment funds can magnify these effects (Bertaut, Bruno and Shin (2023)).

In the example of this subsection we assume that foreign intermediaries hold sovereign bonds denominated in the borrowers' local currency (LC) and obtain funding in their own currency, the foreign currency (FC). Changes in domestic yields and the exchange rate alter the FC value of these holdings, thereby affecting investors' capital positions. When losses occur, a VaR-type constraint limits risk absorption, amplifying the response of sovereign yields to shocks in debt, duration, and the exchange rate.

3.2.1 Foreign investor's holding of local currency bonds

We assume that the foreign investor builds a long position in local currency long-term bonds with price $q_t = Q(r_t)$, yield r_t, and duration $D_t > 0$. With $\Delta q_{t+1} \approx -D_t q_t \Delta r_{t+1}$, the FC-denominated gross profit on the LC bond position between time t and $t+1$ can therefore be approximated by:

$$R^{FC}_{t,t+1} = r^c_t - D_t \Delta r_{t+1} - \Delta s_{t+1} \tag{16}$$

where an increase in $s_t = \ln S_t$ denotes an appreciation of the foreign currency or, equivalently, a depreciation of the local currency. We also assume that yields and the exchange rate have a tendency to comove, so that an increase in domestic bond yields tends to be accompanied by a depreciation of the domestic currency:

$$\Delta s_{t+1} = \psi_t \Delta r_{t+1} + u_{t+1}, \qquad \psi_t \geq 0 \tag{17}$$

where u_{t+1} is a random variable uncorrelated with yields (capturing other factors that influence the exchange rates). This reduced-form relationship captures the typical behavior of FX hedges in response to yield movements. When local-currency yields and volatility rise, investors' bond positions become riskier. Because local bond markets are generally less liquid than FX markets, foreign asset managers often adjust FX hedges ex-post rather than rebalance bond holdings immediately. The resulting decline in hedge demand puts downward pressure on the local currency, leading to depreciation. Even without immediate changes to bond positions, the concurrent rise in yields and currency depreciation increases portfolio risk and lowers demand for local-currency bonds. The rest of the model presented here illustrates the bond rebalancing mechanism.[19]

With assumption (17), the time-t conditional variance of foreign investor's position is:

$$\left(\sigma^{FC}_t\right)^2 \equiv \mathrm{Var}_t\left(R^{FC}_{t+1}\right) = \left(D_t + \psi_t\right)^2 \sigma^2_{r,t} + \sigma^2_{u,t} \tag{18}$$

where $\left(\sigma^{FC}_t\right)^2 \equiv \mathrm{Var}_t\left(R^{FC}_{t+1}\right)$, $\sigma^2_{r,t} \equiv \mathrm{Var}_t(\Delta r_{t+1})$, $\sigma^2_{s,t} \equiv \mathrm{Var}_t(\Delta s_{t+1})$ and $\sigma^2_{u,t} \equiv \mathrm{Var}_t\left(u_{t+1}\right)$.

[19] For a description of recent ex-post hedging episodes, see e.g. Huang et al. (2025) and Shin et al. (2025).

Let h_t^* denote foreign holdings of the LC bond, e_t^* their FC equity and r_t^* the foreign interest rate. The investor chooses h_t^* to maximise expected FC excess returns $\mu_t^{FC} = E_t\left[R_{t+1}^{FC}\right] - r_t^*$ subject to a VaR-type balance-sheet constraint:

$$\max_{h_t^* \geq 0} \mu_t^{FC} h_t^* \quad \text{s.t.} \quad \alpha^* \sigma_t^{FC} q_t h_t^* \leq e_t^* \tag{19}$$

When $\mu_t^{FC} > 0$, the constraint binds and the optimal holding is

$$h_t^* = \frac{e_t^*}{\alpha^* \sigma_t^{FC} q_t} \tag{20}$$

With FC-denominated equity e_t^* and LC bond position h_t^*, the FC mark-to-market change in equity is

$$\Delta e_{t+1}^* = q_t h_t^* (r_t^c - D_t \Delta r_{t+1} - \Delta s_{t+1}) \tag{21}$$

Under the binding VaR constraint (20) and abstracting from carry, $r_t^c \approx 0$, dividends, and new issuance, we obtain:

$$\Delta e_{t+1}^* \approx -\frac{e_t^*}{\alpha^* \sigma_t^{FC}} (D_t \Delta r_{t+1} + \Delta s_{t+1}) \tag{22}$$

The equation above formalises the transmission from bond and exchange-rate shocks to foreign investors' balance sheets. An increase in yields or an unexpected currency depreciation reduces e_t^* through the mark-to-market channel.

3.2.2 Market clearing and pricing

Similarly to the bank-sovereign nexus model of Section 3.1, we assume that there are domestic outside investors with a linear demand, $x_t^O(r_t) = \bar{x}^O + \beta^O(r_t - \bar{r})$. Hence, with total bond supply b_t, a first-order approximation of the market clearing condition $b_t = h_t^* + x_t^O(r_t)$ implies the reduced-form pricing relationship:[20]

$$r_t = r_o + a b_t - \gamma^* e_t^* \tag{23}$$

where the intercept r_o absorbs the constant terms,

$$a \equiv \beta^{-1} = \left(\beta^O + \frac{e^* D}{\alpha^* \sigma^{FC} q}\right)^{-1} \quad \text{and} \quad \gamma^* \equiv \left(\beta \alpha^* \sigma^{FC} \bar{q}\right)^{-1}.$$

[20] The derivation of (23) follows the same steps as for the derivation of the pricing equation in Section 3.1.

Here the slope a captures the inverse of domestic market depth, which depends not only on domestic outside investors but also on the capacity of foreign investors to absorb debt, as captured by the term $\frac{e^*D}{\alpha^*\sigma^{FC}q}$. When yields rise, bond prices fall, allowing foreign investors to increase their holding of LC debt for a given level of equity, thus boosting domestic market depth. Instead, the shifter $-\gamma^* e_t^*$ reflects foreign investors' risk-bearing capacity.

3.2.3 Amplification mechanism

Consider an unexpected rise in domestic yields $\varepsilon_{t+1} \equiv \Delta r_{t+1} > 0$. Given (17) and (22), the foreign investor is hit by a double loss – the drop in the bond price and the loss in its hard-currency value:

$$\Delta e_{t+1}^* = -\frac{e_t^*}{\alpha^*\sigma^{FC}} (D + \psi) \varepsilon_{t+1}$$

Expressed in the investor's currency the duration of its bond portfolio $(D + \psi)$ is therefore greater than the duration in domestic currency. This equity loss tightens the VaR constraint of the foreign investors, which in turn reduces their demand for local currency bonds. At this point, there is an excess supply of bonds in the market which requires an increase in the yield to induce other investors to absorb the bonds and clear the market. Thus, from (23), the yield response is given by:

$$\begin{aligned} \Delta r_{t+1} &= -\gamma^* \Delta e_{t+1}^* = \gamma^* \frac{e_t^*}{\alpha^*\sigma^{FC}} (D + \psi) \varepsilon_{t+1} \\ &= \frac{e_t^* (D + \psi)}{\beta \alpha^{*2} (\sigma^{FC})^2 q} \varepsilon_{t+1}. \end{aligned}$$

Hence, the first-step amplification amounts to:

$$\Gamma^* = \frac{e^* (D + \psi)}{\beta \alpha^{*2} \left((D + \psi)^2 \sigma_r^2 + \sigma_u^2\right) q}$$

Similarly to the bank-sovereign nexus case in Section 3.1, the total amplification effect within the impact period is therefore the sum of geometric series, i.e. $\Delta r_{t+1} = (1 - \Gamma)^{-1} \varepsilon_{t+1}$, provided $\Gamma^* < 1$. Hence, in the "original sin redux" case, amplification rises with foreign investors' equity and market thinness. By contrast, amplification is reduced with longer duration and higher volatility, since these factors tend to lower foreign investors' local currency bond exposure.

3.2.4 Implications for the UIP condition

While not central to the debt sustainability analysis, it is worth noting that the local currency interest rate schedule (23) directly connects to the uncovered interest parity (UIP) condition:

$$r_t - r_t^* = E_t\left[\Delta s_{t+1}\right] + \pi_t^{uip}$$

where the difference in returns is between bonds of the same maturity and the foreign interest rate r_t^* includes a term premium θ_t^*. Substituting (23) and $r_t^* = \bar{r}_{ot}^* + \theta_t^*$ allows us to write the deviation from UIP in terms of risk-free (or short-term) rates as:

$$\pi_t^{uip} = ab_t - \gamma^* e_t^* - \theta_t^*$$

This expression highlights how deviations from UIP may arise endogenously from the interaction between fiscal conditions and investors' balance-sheet strength. The premium increases with public debt b_t and limited market depth (a_t), but decreases when foreign investors are well-capitalised (e_t^* high) or risk tolerance is greater (low γ^*).

3.2.5 Implications for fiscal sustainability

To examine the impact of the "original sin redux" amplification channel on fiscal sustainability, the interest rate schedule (23) can be integrated with the debt dynamics equation (1), a fiscal reaction function (2), and, similarly to Section 3.1, an equation that describes how foreign investors' equity evolves:

$$e_{t+1}^* = (1-\rho_e)e_t^* + \rho_e \bar{e}^* - \frac{e_t^*}{\alpha^* \sigma^{FC}}\left(\left(D+\psi\right)\Delta r_{t+1}\right) \tag{24}$$

where foreign equity gradually returns to its target value $\bar{e}^*$ with speed of adjustment $\rho_e \in (0,1)$.

With a linear fiscal reaction function, the resulting "original sin redux" model is mathematically isomorphic to the bank-sovereign nexus model. Around steady state, both systems reduce to the same two-dimensional linear dynamics in debt and equity. Hence, the computation of the steady states and the analysis of the stability conditions are identical (and the results in Appendix A also apply). What changes is the interpretation of the parameters and their calibration. In the bank-sovereign case, equity refers to domestic banks' capital and the amplification is internal to the domestic financial system. In the "original sin redux" case, equity represents the capital of foreign investors exposed to LC bond and exchange-rate fluctuations, producing an external amplification mechanism. Another key difference is that foreign investors face a greater duration on their bond portfolio than domestic investors through movements in the exchange rate.

Proposition 4: Structural equivalence of the bank-sovereign nexus and the "original sin redux" models. *The bank sovereign nexus model and the "original sin redux" model share the same mathematical structure. Both generate the same nonlinear debt dynamics and endogenous debt limits. The same local stability conditions apply. The key distinction between the two lies in the source and calibration of financial fragility: in the bank-sovereign nexus model, fragility is internal to the domestic banking system, whereas in the "original sin redux" model, it is external, stemming from foreign investors' balance sheets.*

3.3 Duration matching by long-term investors

Long-term institutional investors (LTIs) such as pension funds and life insurers have liabilities that represent a stream of future payments – such as retirement benefits or insurance claims – that need to be made over time. To meet these ongoing obligations, LTIs hold long-term assets – such as government and corporate bonds with extended maturities, because their cash flows more closely match the timing and duration of their future liabilities. Although both sides of their balance sheets have bond-like characteristics, their duration and convexity properties differ. Assets such as long bonds have finite cash-flow horizons so that their duration and convexity can only increase so much when interest rates move. By contrast, many liabilities resemble long-lived or quasi-perpetual commitments, with payments that extend far into the future. This longer tail of cash flows makes liabilities more sensitive to interest rate changes, both in terms of level (higher duration) and how that sensitivity itself changes as rates move (higher convexity). Thus, the duration of liabilities can increase faster than that of the asset portfolio as yields fall, creating a non-linear widening of the duration gap. To address this, LTIs often adjust their bond holdings to maintain a stable funding ratio. Domanski et al. (2017) have shown that this mechanism has contributed to keeping interest rates low for long in Germany in the aftermath of the GFC.

Following Shin (2010), we show that this duration matching can result in a procyclical demand for government bonds if the interest rate is sufficiently low, thereby reducing market depth in sovereign bond markets.

3.3.1 A simple duration-matching example

Consider a pension fund or an insurer investing in a zero-coupon bond with maturity T and price $q(r) = (1+r)^{-T}$ where r is the yield. The duration of this bond is:

$$D_A(r) = -\frac{dq}{dr}\frac{1}{q(r)} = \frac{T}{1+r} \tag{25}$$

Liabilities consist of a stream of constant payments C that decay over time at a constant rate $y < 0$ (as people leave the scheme or pass away). Thus, their present value is given by:

$$L(r) = \sum_{t=0}^{\infty} \frac{C(1+y)^t}{(1+r)^t} = \frac{C}{1 - \frac{1+y}{1+r}} = \frac{C\,(1+r)}{r-y} \tag{26}$$

The term $(r - y)$ appears because discounting at rate r is offset by the growth (or decay) of payments at rate y. When $y < 0$, payments decline over time, so $(r - y)$ is larger and the present value of liabilities smaller.

Bond holdings are denoted by h, so the asset side of the long-term investor is

$$A(r) = hq(r).$$

With the objective of keeping equity immunised against changes in interest rates, duration matching requires that the sensitivity of assets and liabilities to changes in r be equal, $dA/dr = dL/dr$. Solving for $h(r)$ gives the demand for long-term bonds:

$$h(r) = \frac{C(1+r)^{T+1}}{T(r-y)^2} \tag{27}$$

As shown in Domanski et al. (2017), this demand is non-monotonic: the position $h(r)$ rises with r over some interval but decreases in others.

To illustrate this point, log-linearise (27) around a given rate r to obtain:

$$\frac{dh}{h} \approx f(r)dr, \quad f(r) = \frac{T+1}{1+r} - \frac{2}{r-y} \tag{28}$$

There exists a critical threshold

$$r^0 = \frac{(T+1)y+2}{T-1} \tag{29}$$

such that $f(r) < 0$ for $r < r^0$. Below this threshold, bond demand becomes procyclical: pension funds and insurers increase their bond holdings when yields fall, reinforcing price movements. In contrast, for $r \geq r^0$, demand turns stabilising as pension funds and insurers reduce bond exposure when yields rise. Assigning plausible parameters ($T \in [20, 30]$, $y \in [-0.05, -0.02]$) to this example suggests that the threshold lies roughly between 1.5% and 8%, a realistic range for long-term yields.

3.3.2 Interest rate schedule

Let x_t^O denote the bond holdings of other (non-LTI) investors as a ratio to GDP and assume their demand is linear in yields $x^O(r_t) = \bar{x}^O + \beta^O(r_t - \bar{r})$, with $\beta > 0$. The long-term investors' holdings follow from (28):

$$h(r_t) = \bar{h}_0 + \beta^{LTI}(\bar{r})(r_t - \bar{r}) \qquad \beta^{LTI}(\bar{r}) \equiv \bar{h} \cdot f(\bar{r}_t) \tag{30}$$

With b_t denoting the total supply of bonds, market clearing yields the following interest rate schedule:

$$r_t = \delta + ab_t, \quad a \equiv \left(\beta^O + \beta^{LTI}(\bar{r})\right)^{-1}. \tag{31}$$

where the intercept has been replaced by δ similarly to previous examples.

The interest rate schedule (31), combined with the debt dynamic equation (1) and the fiscal reaction function (2), forms a one-dimensional system in b_t, in which the slope of the interest rate curve is regime-dependent. When the fiscal reaction function is linear, solving for the steady state involves a quadratic equation, similar to the approach in Section 3.1 (except for the fact that the model here excludes a role for equity). However, the solution involves some technical nuances. Namely, in computing the steady states, it is necessary to assume whether a is low (or high). This assumption must then be validated by checking that the resulting steady state interest rate exceeds (or falls below) the interest rate threshold r^0. The next Proposition summarises the main takeaway.

Proposition 5: Duration matching reduces market depth and fiscal space in a low interest rate environment. *When long-term institutional investors match the duration of their assets and liabilities, and other investors exhibit linear demand, market depth diminishes in sufficiently low interest rate environments. In such conditions, yield changes are more amplified and markets are thinner compared with higher interest rate environments. All else equal, duration matching in a low rate environment reduces fiscal space, even in the absence of balance sheet losses.*

3.4 Deleveraging in repo markets

A major development post-GFC has been the growing presence of hedge funds in major sovereign bond markets. Post-GFC regulatory reforms have made it costlier for banks to provide unsecured credit and to hold large inventories. As a result, banks have shifted towards offering credit in collateralised form, such as through repo markets, rather than through outright holdings. The expansion of repo markets has thus enabled hedge funds to play an increasingly prominent role in core sovereign debt markets.

Hedge funds frequently engage in arbitrage strategies that seek to profit from small yield differentials, using high leverage to magnify overall returns. In these trades, a hedge fund typically takes a long position in Treasuries and a corresponding short position in futures contracts or interest rate swaps, financing the position through repos. Due to the high correlation between the two legs of the trade, the portfolio's measured volatility appears minimal, resulting in low value-at-risk (VaR) and low – or even zero or negative – margin requirements (Hermes et al. (2025)). Consequently, leverage can expand rapidly in calm markets, compressing perceived risk relative to the true underlying exposure.

However, this dynamic can reverse. When volatility increases or the correlation between the trade's components weakens following some negative news, the perceived VaR of these portfolios rises disproportionately. In response, hedge funds seek to reduce their exposure by unwinding both legs of their trades, leading to large outflows from sovereign securities. At the same time, they scramble to accumulate cash or Treasury bills to meet margin calls, resulting in a "dash for cash". These dynamics were vividly illustrated in March 2020 during the COVID-19 pandemic and again in April 2025 following the announcement by the US administration of a new tariff regime.

This dual role of hedge funds – improving liquidity in normal times but also making it more fragile – has implications for fiscal space. Increased liquidity during tranquil times may indeed create the illusion of greater fiscal space than actually exists, as debt issuance can be easily absorbed with minimal increase in yields. However, in the face of adverse shocks, liquidity can quickly evaporate, and without prompt central bank intervention, this could lead to severe refinancing challenges for fiscal authorities.

This procyclical dynamic and its implications for fiscal space can be illustrated through a simple model, building on Shin (2010) and Aramonte et al. (2023), which we explore below.

3.4.1 Representative Relative Value (RV) hedge fund

Consider a representative hedge fund that engages in a relative value trade between a cash government bond and a futures contract.[21] Let the excess returns on the cash bond and on the futures contract be denoted by the vector $r = (r_1, r_2)^\top$ and assume that their joint distribution is characterised by the vector of expected excess returns $\mu = E(r)$ and the covariance matrix Σ. Given that the volatilities of the two legs of the trade tend to be similar empirically, we can approximate the covariance matrix by

$$\Sigma = \sigma^2 \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}, \tag{32}$$

where σ^2 is the common variance of the two legs and ρ is the correlation between them.[22]

The hedge fund chooses positions in the two assets, collected in the vector $y = (y_1, y_2)^\top$, where y_1 denotes the notional position in the cash bond and y_2 the notional position in the futures contract. The hedge fund is risk-neutral but subject to a VaR constraint on its portfolio (e.g. Shin

[21] We assume that the hedge fund uses futures for the short leg of its trade but in reality other contracts could be used.

[22] This setup is similar to that of Aramonte et al. (2023) in which return variances are assumed to be identical across assets. Here we consider the case of $N = 2$ assets.

(2010)). Let e denote the economic capital allocated to the strategy, and let $\alpha > 0$ capture the tightness of the VaR constraint. The portfolio standard deviation is $\sqrt{y^\top \Sigma y}$, so that the VaR constraint can be written as

$$\alpha\sqrt{y^\top \Sigma y} \leq e, \qquad \text{or equivalently} \qquad \alpha^2 y^\top \Sigma y \leq e^2. \tag{33}$$

The hedge fund finances its cash bond positions through repo borrowing, whereby the purchased bond is pledged with a broker-dealer bank, subject to a haircut. In practice, in several major jurisdictions, most repo funding is conducted with zero or even negative haircuts (Hermes et al. (2025)), suggesting that the size of the hedge fund's portfolio is not constrained by funding availability. Instead, it is primarily limited by internal risk controls, governed by the Value-at-Risk (VaR) constraint.[23]

The hedge fund chooses y to maximise portfolio's expected return $\mu^\top y$ subject to (33). As long as $\mu \neq 0$, the constraint binds at the optimum, so that $y^\top \Sigma y = (e/\alpha)^2$. The associated Lagrangian is

$$\mathcal{L} = \mu^\top y - \lambda \left(y^\top \Sigma y - \left(\frac{e}{\alpha}\right)^2 \right) \tag{34}$$

where $\lambda > 0$ is the Lagrange multiplier. The first–order condition with respect to y is

$$\mu - 2\lambda\, \Sigma y = 0 \quad \Rightarrow \quad y = \frac{1}{2\lambda}\Sigma^{-1}\mu. \tag{35}$$

Replacing this expression in the VaR constraint allows us to solve for the Lagrange multiplier

$$\lambda = \frac{\alpha s}{2e} \tag{36}$$

where

$$s \equiv \sqrt{\mu^\top \Sigma^{-1} \mu} = \sqrt{\frac{\mu_1^2 + \mu_2^2 - 2\rho\mu_1\mu_2}{(1-\rho^2)\sigma^2}}$$

is the efficient Sharpe ratio. This term captures the additional return per unit of volatility that the hedge fund can obtain if the VaR constraint is relaxed at the margin. Using (36) and the inverse of the covariance matrix

[23] Any restrictions on repo funding could be captured in (33) by the availability of risk capital e and/or the VaR tightness α. Alternatively, the availability of repo funding could be formally represented by a funding constraint, $my_1 \leq e$, where m denotes the applied margin or haircut, which must be covered by a portion of the equity. However, since m tends to be small, this constraint is unlikely to be binding in practice.

(32),

$$\Sigma^{-1} = \frac{1}{(1-\rho^2)\sigma^2}\begin{pmatrix} 1 & -\rho \\ -\rho & 1 \end{pmatrix}, \tag{37}$$

we obtain the optimal portfolio

$$y^* = \frac{\kappa}{(1-\rho^2)\sigma^2}\begin{pmatrix} \mu_1 - \rho\mu_2 \\ -\rho\mu_1 + \mu_2 \end{pmatrix}, \tag{38}$$

where the scaling factor κ is determined by the binding VaR constraint and is given by

$$\kappa = \frac{e}{\alpha}\frac{1}{\sqrt{\mu^\top \Sigma^{-1}\mu}} = \frac{e}{\alpha}\sqrt{\frac{(1-\rho^2)\sigma^2}{\mu_1^2 + \mu_2^2 - 2\rho\mu_1\mu_2}}. \tag{39}$$

It is convenient to decompose this expression into a common–factor component and a relative–value component. Let $\bar{\mu} = (\mu_1 + \mu_2)/2$ denote the average return and $\Delta\mu = \mu_1 - \mu_2$ the spread between the cash bond and the futures contract. Then $\mu_1 - \rho\mu_2 = (1-\rho)\bar{\mu} + \frac{1+\rho}{2}\Delta\mu$ and $-\rho\mu_1 + \mu_2 = (1-\rho)\bar{\mu} - \frac{1+\rho}{2}\Delta\mu$. Substituting back into (38) and simplifying, the optimal positions in the cash bond and the futures can be written as:

$$y^* = \frac{e}{\alpha\sigma}\frac{1}{\sqrt{A(\rho)}}\left[\underbrace{\sqrt{\frac{1-\rho}{1+\rho}}\bar{\mu}\begin{pmatrix} 1 \\ 1 \end{pmatrix}}_{\text{Common risk factor}} + \underbrace{\sqrt{\frac{1+\rho}{1-\rho}}\frac{\Delta\mu}{2}\begin{pmatrix} 1 \\ -1 \end{pmatrix}}_{\text{Relative value}}\right] \tag{40}$$

with $A(\rho) = 2(1-\rho)\bar{\mu}^2 + \frac{1+\rho}{2}\Delta\mu^2$.

The optimal portfolio is made up of two parts: a directional position on the common risk factor and a relative-value position on the spread. When the average expected return $\bar{\mu}$ is positive, the hedge fund takes a symmetric long position in both legs. However, as the correlation ρ increases, this symmetric position becomes less attractive because it entails greater exposure to the same risk, while the long-short component that exploits the spread $\Delta\mu$ becomes more appealing. Moreover, leverage y_1^*/e increases non-linearly with ρ, reaching disproportionally high levels when it approaches unity. This captures the idea that in tranquil and highly correlated markets, hedge funds optimally run large highly leveraged relative value trades. Yet this also implies that even a small decline in correlation can lead to a disproportionally large reduction in leverage. Besides, ρ, leverage also increase when the VaR constraint is less tight (lower α) and market volatility σ is low.

To simplify the analysis, we assume that $\bar{\mu} \approx 0$. This can be justified, for example, by considering that the hedge fund offsets the common component using other hedging instruments not included in this model. With $\Delta\mu > 0$, the optimal portfolio simplifies to a pure relative trade, corresponding to the following demand for government bonds:

$$h_t = y_1^* = \frac{e_t}{\alpha \sigma_t q_t \sqrt{2\,(1-\rho_t)}} \tag{41}$$

and an equal short futures position, $y_2^* = -y_1^*$.[24] Here, consistent with the notation from previous sections, the notional amount is the product of the bond price q_t and the unit of bonds h_t. Time subscripts have also been added to the variables, as they will be useful in analysing the amplification effects implied by the relative value trade.

For tractability, equity is assumed to be fully elastic so that

$$e_t = \bar{e} \tag{42}$$

Mark-to-market losses are immediately replenished by investors, while gains are promptly distributed. Thus, equity neither accumulates nor constitutes a state variable, unlike in the previous examples. This assumption shuts down an important channel of amplification but allows us to show how market volatility interacts with hedge funds' activities to amplify changes in yields.

Correlation is assumed to adjust instantaneously to market stress:

$$\rho_t = \bar{\rho} - \zeta \sigma_t \tag{43}$$

where $\zeta > 0$ and bounds imposed to ensure $\rho_t \in (0, 1)$. This reduced form relationship reflects the empirical observation that, in stressed market conditions, basis risk rises and hedges become less effective. With this specification, an increase in market stress simultaneously raises measured volatility and reduces correlation, tightening the VaR constraint through both channels. We adopt this parsimonious specification for tractability, for it preserves the economic role of correlation without introducing additional state variables.

To capture stress dynamics, let market-wide volatility respond to yield

[24] Note that the expected return differential does not appear in (41): provided $\Delta\mu > 0$, leverage – and hence the demand for bonds – is determined only by risk capacity.

movements:

$$\sigma_{t+1} = (1-\upsilon)\,\sigma_t + \upsilon\bar{\sigma} + \omega\,|\Delta r_{t+1}| \tag{44}$$

with $\omega > 0$. This specification captures the idea that large price movements and one-sided order flows – regardless of the sign – raise realised volatility and impair market liquidity.[25]

3.4.2 Market clearing and pricing

Let us assume the existence of outside investors with an elastic demand for bonds, $x^O(r_t) = \bar{x}^O + \beta^O(r_t - \bar{r})$ with $\beta^O > 0$, and denote the supply of bonds with b_t. Using (41)-(43), a first-order approximation of the market clearing gives an interest rate schedule that depends on public debt and market volatility:

$$r_t = r^* + a\,b_t + r_\sigma \sigma_t \tag{45}$$

where the intercept r^* absorbs the constant terms and

$$\begin{aligned} a &\equiv \frac{1}{\beta} \equiv \frac{1}{\beta^O + hD}, \qquad r_\sigma \equiv \frac{h}{\beta}\left(\frac{1}{\bar{\sigma}} + \frac{\zeta}{2\,(1-\bar{\rho}+\zeta\bar{\sigma})}\right), \\ h &\equiv \frac{\bar{e}}{\alpha\bar{\sigma}q\sqrt{2\,(1-\bar{\rho}+\zeta\bar{\sigma})}}. \end{aligned}$$

The slope a reflects both the depth of outside demand and the additional depth created by hedge funds' demand. When yields rise, outside investors absorb more bonds because their demand is upward sloping in r. At the same time, hedge funds also acquire more bonds, because the lower bond price lets them buy more bonds for the same level of risk capital. Together, these effects increase market depth and lower the slope of the interest rate curve. The coefficient r_σ reflects the net effect of two channels: a deleveraging channel, whereby higher volatility forces hedge funds to unwind positions and pushes yields up, and a stabilising market-depth channel, whereby lower bond prices allow a given stock of hedge fund capital to absorb more bonds, partly offsetting the rise in yields.

3.4.3 Amplification mechanism

Consider an exogenous increase in sovereign yields at time $t+1$, denoted by an initial shock $\varepsilon_{t+1} > 0$, which may originate from fiscal news, global

[25] To ensure differentiability and a well-defined Jacobian, the analysis below focuses only on the case of adverse shocks to yields such that $\Delta r_{t+1} \geq 0$.

financial conditions or a shift in risk sentiment. The shock is assumed to be large enough to produce one-sided flows and raise market volatility: thus, from (44), $\Delta\sigma_{t+1} = \omega\varepsilon_{t+1}$. The rise in volatility, in turn, weakens the correlation between the cash bonds and the futures legs of the hedge fund's trade, as implied by (43). This reduced correlation, combined with higher volatility, increases the VaR of the hedge fund portfolio, prompting the hedge fund to deleverage. From (45), this effect is:

$$\Delta r_{t+1} = r_\sigma \Delta\sigma_{t+1} = r_\sigma \omega \varepsilon_{t+1}$$

As the higher yield feeds back into volatility through (44), it generates a further increase in volatility, which puts additional pressure on yields. At a steady state, the overall yield effect on impact is therefore given by $\Delta r_{t+1} = \left(1 + \omega r_\sigma + (\omega r_\sigma)^2 + ...\right)\varepsilon_{t+1} = (1 - \omega r_\sigma)^{-1}\varepsilon_{t+1}$, provided $\omega r_\sigma < 1$. Amplification is therefore stronger, the larger is the sensitivity of volatility to yield changes ω, the larger is r_σ, and the smaller is outside-investor market depth.[26]

3.4.4 Implications for fiscal sustainability

Combining the interest rate schedule (45) with the debt dynamic equation (1) yields a two-dimensional system in public debt and market volatility. Using (42) together with the approximation $\frac{1+x}{1+y} \simeq 1 + x - y$ and defining $\delta \equiv r^* - g$, we can approximate debt dynamics as:

$$b_{t+1} = (1 + \delta + ab_t + r_\sigma \sigma_t)b_t - s(b_t) \tag{46}$$

In steady state, $\Delta r = 0$ so that $\sigma = \bar{\sigma}$, and $b_{t+1} = b_t = b$. The steady

[26]Beyond the mechanism modelled here, re-hypothecation in the repo markets provides an additional amplification channel. Broker-dealers extend funding against government bonds posted as collateral and then re-use that collateral to secure further financing from other institutions. These collateral chains expand system-wide debt capacity beyond the initial loan, effectively multiplying leverage. As shown in a debt accounting framework by Aramonte et al. (2023), leverage begets leverage. To illustrate this point, consider a single bond posted into repo with margin m. The first round of borrowing is $(1-m)\,qh$. If a fraction $\zeta \in [0,1)$ of the collateral is re-pledged downstream with the same margin m, the second round of borrowing is $\zeta(1-m)^2\,qh$ and so forth. Applying this logic shows that the total system-wide borrowing capacity against the same underlying collateral is $R\,(m,\zeta) = \frac{1}{1-\zeta(1-m)}$. This is the single bond analogue of the debt capacity recursion in Aramonte et al. (2023), which generalises to multiple assets and intermediaries in matrix form. In calm states (low m, high ζ), R is large; in stress, R collapses as funding evaporates and investors meet margin calls by selling risky collateral and rotating into cash. Deleveraging and the dash for cash are therefore two manifestations of the same constraint (Aramonte, Schrimpf and Shin (2023)).

state condition then becomes $s(b) = (\delta + r_\sigma \bar{\sigma}) b + ab^2$, which has the same quadratic structure as in the bank-sovereign nexus model in Section 3.1. Hence, we can state the following proposition.

Proposition 6: Steady state and local stability in the repo deleveraging model. *Assume the fiscal reaction function is linear* $s(b) = \hat{s} + \phi b$ *with* $\hat{s} < 0$*, and that the interest rate schedule implies a convex interest cost term in debt (i.e.* $a > 0$*). If the discriminant condition holds, then there exists two steady state equilibria* $0 < b^s < \bar{b}$ *corresponding to the roots of the quadratic equation* $ab^2 + (\delta + r_\sigma \bar{\sigma} - \phi) b - \hat{s} = 0$*. The upper steady state* $\bar{b}$ *is unstable and can be interpreted as an endogenous debt limit. The lower steady state* b^s *is locally stable if the following key conditions hold:*[27]

$$\phi > R(b^s) \equiv \delta + r_\sigma \bar{\sigma} + 2ab^s + \underbrace{\frac{\omega r_\sigma a b^s - \upsilon}{1 - \omega r_\sigma - \upsilon}}_{\text{financial fragility premium}} \tag{47}$$

$$\omega r_\sigma < 1 - \upsilon \tag{48}$$

where ω *denotes the impact of a sovereign yield shock to volatility and* r_σ *is the yield's sensitivity to volatility.*

Stability requires a sufficiently responsive fiscal policy that can offset both the baseline increase in interest payments implied by long–term structural factors and the additional interest burden that arises when financial conditions tighten due to repo–driven deleveraging. Condition (48) ensures that volatility mean reversion dominates the endogenous feedback between yields and volatility generated by hedge fund deleveraging. If the sensitivity of volatility to yield changes were too large relative to the speed of mean reversion, small shocks would generate self-reinforcing increases in volatility and sovereign spreads.

[27] These stability conditions are derived following the same steps outlined in Appendix A (not shown here). A further technical condition puts an upper bound on ϕ:

$$\phi < 2 + \delta + r_\sigma \bar{\sigma} + 2ab^s + \frac{2\omega r_\sigma \cdot ab^s}{2(1 - \omega r_\sigma) - \nu}.$$

Proposition 7: Steady-state fiscal space in the repo deleveraging model. *The distance between the two steady states*

$$FS = \bar{b} - b^s = \frac{\sqrt{\Delta}}{a}, \qquad \Delta \equiv (\delta + r_\sigma \bar{\sigma} - \phi)^2 + 4a\hat{s} \tag{49}$$

represents fiscal space in the absence of shocks. In the economically relevant region $\phi > \delta + r_\sigma \bar{\sigma}$, steady-state fiscal space increases with a lower risk-free growth-adjusted interest rate δ, a stronger fiscal response ϕ, greater market depth (lower a) and greater sensitivity of yields to volatility r_σ. The effects of stronger hedge fund risk-bearing capacity – whether through higher $\bar{e}$ or lower α – are ambiguous, because it simultaneously deepens the market and increases the sensitivity of yields to volatility. The effect of steady-state volatility $\bar{\sigma}$ is likewise ambiguous once its impact on market depth and volatility sensitivity is taken into account.

The reason why hedge fund risk-bearing capacity has an ambiguous impact on steady-state fiscal space is that $\bar{e}$ and α affect both the sensitivity of yields to volatility r_σ – reflecting hedge deleveraging – and market depth through the slope coefficient a. That said, the market depth channel is overstated in the current model given the assumption of a fixed equity $\bar{e}$. Moreover, the deleveraging channel should dominate in practice.

The next proposition shows that the state-contingent nature of fiscal space derived in the bank-sovereign nexus model carries over to the hedge fund deleveraging framework of this section.

Proposition 8: State-contingent fiscal space under repo-market deleveraging. *Suppose the economy is initially at the stable steady state. Let $\varepsilon_{t+1} > 0$ denote a positive exogenous shock to the sovereign yield. Then the impact response of fiscal space is approximately*

$$FS_{t+1} - FS(\bar{\sigma}) \approx FS'_\sigma(\bar{\sigma}) \cdot \frac{\omega}{1 - \omega r_\sigma} \varepsilon_{t+1}$$

where $FS'_\sigma(\bar{\sigma})$ denotes the derivative of steady-state fiscal space with respect to volatility, evaluated at $\bar{\sigma}$.

Over the economically relevant region, where $\phi > \delta + r_\sigma \bar{\sigma}$ and $\omega r_\sigma < 1$, and provided that volatility-induced deleveraging is sufficiently strong, FS'_σ is negative. Hence a positive yield shock reduces fiscal space. The reduction is stronger when the volatility-spread feedback, captured by $\omega(1 - \omega r_\sigma)^{-1}$, *is larger. Moreover, provided the deleveraging channel is sufficiently strong, the contraction in fiscal space from a given shock tends to be larger when steady-state fiscal space is smaller.*

More generally, the response of fiscal space over time can be approximated by

$$FS_{t+h} - FS(\bar{\sigma}) \approx FS'(\bar{\sigma}) \cdot e_2' J^{h-1} e_2 \cdot \frac{\omega}{1 - \omega r_\sigma} \cdot \varepsilon_{t+1}, \qquad h \geq 1$$

where J is the Jacobian matrix of the linearised (b_t, σ_t) system. The persistence of the contraction in the fiscal space inherits the persistence of debt and volatility.

A key implication of the above analysis is that the state-contingent nature of fiscal sustainability derived earlier does not depend on the specific structure of the bank-sovereign nexus. When sovereign debt is intermediated by leveraged market participants in repo markets, volatility-induced deleveraging can similarly amplify yield shocks and compress fiscal space.

4 Conclusion

This paper highlights the impact that financial institutions' balance sheet constraints and financial amplification mechanisms could have on fiscal space, thus stressing the importance of explicitly incorporating them into debt sustainability analyses. The aim is not to build an exhaustive model, but to demonstrate in a transparent way the key channels through which financial factors influence fiscal outcomes. Future research could therefore build on these foundations to develop richer and more realistic models that could be calibrated to provide a more accurate assessment of fiscal space.

At least two other avenues for future research could be envisaged. One is to integrate our balance sheet-driven fiscal limit with models that feature explicit sovereign default and self-fulfilling liquidity crises. In our framework, credit risk is implicit and emerges endogenously when financial intermediation capacity and hence fiscal space are exhausted, whereas in standard sovereign default models liquidity interacts with an explicit default decision. Such an extension could clarify whether financial fragility amplifies, substitutes for, or even precipitates belief-driven crises.

Another natural avenue for research involves the role of central banks.

Central banks have intervened successfully in recent liquidity crises, restoring market functioning. However, their capacity to intervene is not unlimited. Such actions can sometimes increase market distortions, encourage moral hazard, and lead to greater leverage. Even if central bank interventions can resolve short-term liquidity issues, they may not prevent a gradual decline in financial stability or the financial system's ability to absorb public debt over longer horizons. Moreover, large and frequent interventions and the resulting larger central bank balance sheets may ultimately come into conflict with long-term monetary policy objectives. Thus, a key research priority is to understand the limits of central bank intervention, when and how they can lose effectiveness in the face of ongoing fiscal and financial fragility and how these limits and effectiveness translate into limits on fiscal space.

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Appendix A

A1. Local stability conditions in the bank-sovereign nexus model

The model of Section 3.1 comprises the following equation:

$$r_t = \delta + ab_t - \gamma e_t, \tag{50}$$

$$b_{t+1} = (1 + \delta + ab_t - \gamma e_t)b_t - s(b_t), \tag{51}$$

$$e_{t+1} = (1 - \rho_e)e_t + \rho_e \bar{e} - \eta e_t \Delta r_{t+1}, \tag{52}$$

where

$$\begin{aligned} \delta &\equiv r^* - g, \\ \Delta r_{t+1} &\equiv r_{t+1} - r_t, \\ a &\equiv \beta^{-1} \\ \gamma &\equiv (\beta\alpha\sigma Dq)^{-1} \\ \eta &\equiv (\alpha\sigma)^{-1} \end{aligned}$$

Note that $\Gamma \equiv \gamma\eta\bar{e} \equiv \zeta a\bar{e}$ is a term that governs the amplification of yield movement following an initial shock evaluated at the steady state (as defined in (11)). The notational equivalence follows from $\zeta \equiv (\alpha^2\sigma^2 Dq)^{-1}$ (see equation (13)).

Linearising (51) and (52) around the steady state gives:

$$\begin{aligned} \tilde{b}_{t+1} &= (1 + \delta + 2ab - \gamma\bar{e} - s_b')\, \tilde{b}_t - \gamma b\tilde{e}_t \\ &\equiv A\tilde{b}_t + C\tilde{e}_t \\ \tilde{e}_{t+1} &= (1 - \rho_e)\, \tilde{e}_t - \eta\bar{e}\Delta\tilde{r}_{t+1} \end{aligned}$$

Noting that $\Delta\tilde{r}_{t+1} = a\Delta\tilde{b}_{t+1} - \gamma\Delta\tilde{e}_{t+1}$ from (50) and substituting in, the equity block can be rewritten as:

$$\begin{aligned} \tilde{e}_{t+1} &= \frac{(1-\rho_e) - \eta\bar{e}\gamma}{1 - \eta\bar{e}\gamma}\tilde{e}_t - \frac{\eta\bar{e}a}{1-\eta\bar{e}\gamma}\left(\tilde{b}_{t+1} - \tilde{b}_t\right) \\ &\equiv K\tilde{e}_t - \Upsilon\Delta\tilde{b}_{t+1} \end{aligned}$$

Substitute in $\tilde{b}_{t+1}$ gives:

$$\begin{aligned} \tilde{e}_{t+1} &= K\tilde{e}_t - \Upsilon\Delta\tilde{b}_{t+1} = K\tilde{e}_t - \Upsilon\left(A\tilde{b}_t + C\tilde{e}_t\right) + \Upsilon\tilde{b}_t = \\ &\equiv (K - \Upsilon C)\,\tilde{e}_t + \Upsilon\,(1 - A)\,\tilde{b}_t \end{aligned}$$

We can now write the two equation as a two-dimensional system:

$$\begin{pmatrix} \tilde{b}_{t+1} \\ \tilde{e}_{t+1} \end{pmatrix} = \begin{pmatrix} A & C \\ \Upsilon (1-A) & (K - \Upsilon C) \end{pmatrix} \begin{pmatrix} \tilde{b}_t \\ \tilde{e}_t \end{pmatrix} \tag{53}$$

For a 2×2 linear system, local stability (both eigenvalues inside the unit circle) requires the standard Jury conditions are met:

$$1 - Tr(J) + \det(J) > 0 \tag{54}$$

$$1 + Tr(J) + \det(J) > 0 \tag{55}$$

$$1 - \det(J) > 0 \tag{56}$$

From $1 - Tr(J) + \det(J)$ we obtain:

$$1 - (A + (K - \Upsilon C)) + (A(K - \Upsilon C) - C\Upsilon(1 - A)) > 0$$

which, after some algebra, boils down to

$$\begin{aligned} (1-A)(1-K) &> 0 \\ (s_b' - (\delta + 2ab - \gamma\bar{e}))\left(\frac{\rho_e}{1 - \eta\gamma\bar{e}}\right) &> 0 \end{aligned}$$

Thus, provided $1 - \eta\gamma\bar{e} > 0$, condition (54) boils down to:

$$s_b' > \delta + 2ab - \gamma\bar{e} \tag{57}$$

The condition $1 - \eta\gamma\bar{e} > 0$ (or $\Gamma < 1$) must hold otherwise a positive shock to the interest rate would lead to an increase in equity rather than a loss.

The condition $1 - \det(J) > 0$ implies:

$$s_b' > \delta + 2ab - \gamma\bar{e} + \frac{\gamma\eta\bar{e}ab - \rho_e}{(1 - \rho_e) - \gamma\eta\bar{e}} \tag{58}$$

The condition $1 + \mathrm{Tr}(J) + \det(J) > 0$ becomes:

$$s_b' < 2 + \delta + 2ab - \gamma\bar{e} + \frac{2\gamma\eta\bar{e}ab}{2 - \rho_e - 2\gamma\eta\bar{e}} \tag{59}$$

This condition puts an upper bound on fiscal response.

In the main text, the model is solved assuming a linear fiscal reaction function, $s(b_t) = \hat{s} + \phi b_t$, so that $s_b' = \phi$. With this assumption, the steady state equilibria solves the quadratic equation,

$$ab^2 + (\delta - \gamma\bar{e} - \phi)\, b - \hat{s} = 0.$$

With $\hat{s} < 0$ and $\Delta = (\delta - \gamma\bar{e} - \phi)^2 + 4a\hat{s} > 0$, the quadratic equation admits solutions $0 < b^s < \bar{b}$:

$$\begin{aligned}\bar{b} &= \frac{1}{2a}\left(-(\delta - \gamma\bar{e} - \phi) + \sqrt{\Delta}\right)\\ b^s &= \frac{1}{2a}\left(-(\delta - \gamma\bar{e} - \phi) - \sqrt{\Delta}\right)\end{aligned}$$

We now demonstrate that the upper root is unstable $\bar{b}$ and hence can be interpreted as a debt limit, beyond which debt would grow unchecked. Substituting $\bar{b}$ out of (57) yields:

$$\phi > \delta - \gamma\bar{e} + 2a\bar{b} \quad \Longrightarrow \phi > \phi + \sqrt{\Delta}$$

Given $\Delta > 0$, the stability condition is violated, confirming that $\bar{b}$ is an unstable equilibrium.

For the lower root to be stable, all conditions (57)-(59) need to be satisfied. Evaluating (57) at b^s shows that this condition is satisfied:

$$\phi > \delta - \gamma\bar{e} + 2ab^s \quad \Longrightarrow \phi > \phi - \sqrt{\Delta} \quad \Longrightarrow \Delta > 0$$

Hence, local stability for b^s boils down to check conditions (58) and (59). Using the fact $\gamma\eta = \zeta a$, these can be rewritten as:

$$\phi > \delta - \gamma\bar{e} + 2ab^s + \frac{\zeta a\bar{e} \cdot ab^s - \rho_e}{1 - \zeta a\bar{e} - \rho_e}, \qquad \zeta \equiv \frac{1}{\alpha^2\sigma^2 Dq} \tag{60}$$

$$\phi < 2 + \delta - \gamma\bar{e} + 2ab^s + \frac{2\zeta a\bar{e} \cdot ab^s}{2\left(1 - \zeta a\bar{e}\right) - \rho_e}$$

which is condition (13) in the main text.

A2. Comparative statics analysis

Below we show that the steady-state fiscal space is increasing in bank equity in the bank-sovereign nexus model of Section 3.1.

Recall that steady-state fiscal space is given by

$$FS(\bar{e}) = \frac{\sqrt{\Delta(\bar{e})}}{a(\bar{e})}, \tag{61}$$

where

$$\Delta(\bar{e}) \equiv \psi(\bar{e})^2 + 4a(\bar{e})\hat{s}, \tag{62}$$

and

$$\psi(\bar{e}) \equiv \delta - \phi - \gamma(\bar{e})\bar{e}. \tag{63}$$

Differentiating $FS(\bar{e})$ with respect to $\bar{e}$ gives

$$FS_e \equiv \left.\frac{dFS(e)}{de}\right|_{e=\bar{e}} = \frac{a(\bar{e})\psi(\bar{e})\psi_e - a_e\left[\psi(\bar{e})^2 + 2a(\bar{e})\hat{s}\right]}{a(\bar{e})^2\sqrt{\Delta(\bar{e})}}, \tag{64}$$

where

$$a_e \equiv \left.\frac{da(e)}{de}\right|_{e=\bar{e}}, \qquad \gamma_e \equiv \left.\frac{d\gamma(e)}{de}\right|_{e=\bar{e}}, \qquad \psi_e \equiv \left.\frac{d\psi(e)}{de}\right|_{e=\bar{e}}. \tag{65}$$

Since $\psi(e) = \delta - \phi - \gamma(e)e$, it follows that $\psi_e = -\left[\gamma(\bar{e}) + \bar{e}\,\gamma_e\right]$. Using the definition of the coefficients in the interest rate schedule (10), $a(e) = \left(\beta_O + \frac{e}{\alpha\sigma q}\right)^{-1}$ and $\gamma(e) = \frac{a(e)}{\alpha\sigma D q}$, we obtain

$$a_e = -\frac{1}{\alpha\sigma q}a(\bar{e})^2 < 0, \tag{66}$$

and

$$\gamma_e = \frac{a_e}{\alpha\sigma D q} < 0. \tag{67}$$

Substituting for γ_e into ψ_e yields

$$\psi_e = -\frac{a(\bar{e}) + \bar{e}a_e}{\alpha\sigma D q}. \tag{68}$$

Now note that

$$a(\bar{e}) + \bar{e}a_e = a(\bar{e})\left(1 - \frac{\bar{e}\,a(\bar{e})}{\alpha\sigma q}\right). \tag{69}$$

Using $a(\bar{e}) = \left(\beta_O + \frac{\bar{e}}{\alpha\sigma q}\right)^{-1}$,we obtain

$$\frac{\bar{e}\,a(\bar{e})}{\alpha\sigma q} = \frac{\bar{e}/(\alpha\sigma q)}{\beta_O + \bar{e}/(\alpha\sigma q)} < 1. \tag{70}$$

Therefore,

$$a(\bar{e}) + \bar{e}a_e > 0, \tag{71}$$

which implies

$$\psi_e < 0. \tag{72}$$

Consider next the economically relevant region $\phi > \delta - \gamma(\bar{e})\bar{e}$. This implies

$$\psi(\bar{e}) = \delta - \phi - \gamma(\bar{e})\bar{e} < 0. \tag{73}$$

Moreover, since $\Delta(\bar{e}) = \psi(\bar{e})^2 + 4a(\bar{e})\hat{s} > 0$, we have

$$\psi(\bar{e})^2 + 2a(\bar{e})\hat{s} = \frac{\psi(\bar{e})^2 + \Delta(\bar{e})}{2} > 0. \tag{74}$$

We can now sign the numerator of FS_e. First,

$$a(\bar{e})\psi(\bar{e})\psi_e > 0, \tag{75}$$

because $a(\bar{e}) > 0$, $\psi(\bar{e}) < 0$, and $\psi_e < 0$. Second,

$$-\,a_e\left[\psi(\bar{e})^2 + 2a(\bar{e})\hat{s}\right] > 0, \tag{76}$$

because $a_e < 0$ and $\psi(\bar{e})^2 + 2a(\bar{e})\hat{s} > 0$.

Therefore, both terms in the numerator of FS_e are positive. Since the denominator is also positive, it follows that

$$FS_e > 0. \tag{77}$$

Thus, stronger bank equity unambiguously increases steady-state fiscal space.

A3. Dynamic fiscal space analysis

To analyse how fiscal space deviates from its steady state level after a positive shock to sovereign yields, write the fiscal space as a function of bank equity:

$$FS\left(e\right) = \frac{\sqrt{\Delta\left(e\right)}}{a\left(e\right)}, \qquad \Delta\left(e\right) \equiv \left(\delta - \gamma\left(e\right)e - \phi\right)^2 + 4a\left(e\right)\hat{s}.$$

Because both $a\left(e\right)$ and $\gamma\left(e\right)$ depend on bank equity through market depth, the derivative of fiscal space with respect to equity must take this dependence into account. As shown in Appendix A2,

$$FS_e'\left(\bar{e}\right) > 0$$

in the region $\phi > \delta - \gamma\left(e\right)e$.

A first-order approximation around the stable steady state therefore gives

$$FS_{t+h} - FS\left(\bar{e}\right) \approx FS_e'\left(e_{t+h} - \bar{e}\right), \qquad h \geq 1.$$

Consider now a positive shock ε_{t+1} to the interest rate r_{t+1}. From (50), we can write

$$\Delta r_{t+1} + \gamma \Delta e_{t+1} = a \Delta b_{t+1} + \varepsilon_{t+1}$$

The variables can be expressed in deviations from their respective steady state values, i.e. $\tilde{r}_{t+1} + \gamma \tilde{e}_{t+1} = \varepsilon_{t+1}$, noting that $\Delta \tilde{b}_{t+1} = \tilde{b}_{t+1} = 0$. From (52), the initial deviation of equity from its steady state is

$$\tilde{e}_{t+1} = -\eta \bar{e} \cdot \tilde{r}_{t+1}.$$

Substituting and solving gives

$$\begin{aligned} \tilde{r}_{t+1} + \gamma \left(-\eta\right) \bar{e} \cdot \tilde{r}_{t+1} &= \varepsilon_{t+1} \\ \tilde{r}_{t+1} &= \frac{1}{1 - \zeta a \bar{e}} \cdot \varepsilon_{t+1} \end{aligned}$$

where $\gamma \eta \equiv \zeta a$. Hence

$$\tilde{e}_{t+1} = \frac{-\eta \bar{e}}{1 - \zeta a \bar{e}} \cdot \varepsilon_{t+1} \tag{78}$$

Given this initial impulse, the responses of $\tilde{b}_{t+h}$ and $\tilde{e}_{t+h}$ for $h \geq 1$ can be obtained by iterating on (53). The contraction of fiscal space following a shock to the yield can therefore be written as:

$$FS_{t+1} - FS\left(\bar{e}\right) \approx F_e'\left(\bar{e}\right) \cdot \frac{-\eta \bar{e}}{1 - \zeta a \bar{e}} \cdot \varepsilon_{t+1} < 0$$

for the economically relevant region $\phi > \delta - \gamma \bar{e}$ and provided the financial stability boundary is not breached, i.e. $\zeta a \bar{e} < 1$.

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