DEBT DYNAMICS ACROSS DEVELOPED ECONOMIES: A COMPARATIVE DECOMPOSITION OF R-G, PRIMARY BALANCES, AND STOCK–FLOW ADJUSTMENTS IN JAPAN, THE UNITED STATES, AND EUROPE

Masaaki Yoshimori
McCourt School of Public Policy, Georgetown University, 125 E St NW, Washington, DC 20001, USA
my612@georgetown.edu

Abstract
This paper reexamines public debt dynamics in advanced economies using an accounting-based framework explicitly conditioned on rare crisis states. Conventional sustainability narratives and debt models treat the interest–growth differential as the central determinant of debt dynamics. This paper argues that this emphasis is misleading: the episodes responsible for most long-run debt accumulation—financial crises, pandemics, and large-scale interventions—are precisely those in which fiscal actions and stock–flow adjustments dominate.
Exploiting the government debt identity, the analysis decomposes changes in debt-to-GDP ratios into snowball, primary-balance, and stock–flow components. Using annual data for eight advanced economies from 1980 to 2023, the paper applies finite-sample, nonparametric tools to identify which components organize realized debt increases in debt-defining years.
The results are stark. While the snowball term is mechanically valid, it rarely aligns with observed debt increases and never dominates their magnitude. Instead, debt surges are driven by fiscal actions and stock–flow adjustments concentrated in crisis states, implying that debt sustainability is governed by crisis management rather than snowball arithmetic.

Key words: *Public debt dynamics, Debt sustainability, Interest–growth differential, Fiscal crises, Accounting decomposition*

JEL Classification: *C14, E44, E62, H12, H63*

I. Introduction

Public debt ratios in advanced economies have risen to historically elevated levels, yet the mechanisms governing debt accumulation remain poorly understood. Much of the academic and policy debate continues to frame debt dynamics through steady-state arithmetic, emphasizing smooth compounding and long-run averages. Within this view, sustainability is often inferred from tranquil-period conditions, implicitly assuming that debt evolves gradually and predictably. However, historical experience suggests that this characterization is incomplete. Large increases in public debt have tended to occur not through incremental drift, but through rare, high-impact episodes associated with financial crises, deep recessions, and large-scale stabilization interventions (Reinhart and Rogoff, 2009, 2011).

A growing macro-financial literature documents that these crisis episodes are not peripheral, but central to long-run debt outcomes. Using long historical datasets, Jordà, Schularick, and Taylor (2016, 2017) show that modern business cycles are increasingly shaped by financial booms and busts, with crisis states generating persistent macroeconomic and fiscal scars. Debt accumulation is therefore highly episodic: a small number of stress years account for a disproportionate share of cumulative debt increases, while debt changes in normal times are comparatively modest. This empirical regularity challenges approaches that rely primarily on average conditions or asymptotic convergence logic.

At the same time, the instruments that governments use to stabilize economies during crises have shifted decisively toward balance-sheet-intensive interventions. Financial rescues, public guarantees, asset purchases, and liquidity backstops have become standard components of crisis management in advanced economies. These policies often operate outside conventional budget flows and transmit to public debt through valuation effects, reclassifications, and other stock–flow adjustments. Work on sovereign–financial sector linkages emphasizes that such balance-sheet interactions can dominate fiscal dynamics during stress episodes, creating powerful feedback loops between governments and financial systems (Farhi and Tirole, 2018; Bolton and Jeanne, 2011; Gorton and Metrick, 2012).

These developments raise a methodological concern. Standard econometric approaches to debt sustainability typically require repeated crisis realizations, stable regime behavior, or long time series to identify state-dependent dynamics. Yet crisis episodes are few, heterogeneous, and often coincide with institutional and

accounting changes. As a result, coefficient-centric estimation may be ill-suited to identifying the mechanisms that matter most for long-run debt outcomes. More fundamentally, the relevant variation in debt dynamics is concentrated in tail events rather than in average years, suggesting that inference should be organized around those states rather than around tranquil-period moments.

This paper supports an alternative perspective on public debt dynamics. Rather than estimating parametric debt equations, it treats debt accumulation as an accounting problem conditioned on rare crisis states. Using the government debt identity, changes in the debt-to-GDP ratio are decomposed into a mechanical component tied to inherited debt, a fiscal flow component, and a residual capturing balance-sheet operations and stock–flow adjustments. The empirical strategy relies on finite-sample distributional evidence—event-study comparisons, sign-frequency tests, and dominance statistics—to identify which components empirically organize debt increases in debt-defining years. This approach aligns with the macro-financial literature emphasizing crisis dynamics, nonlinear adjustment, and the limits of smooth-transition narratives (Hall and Sargent, 2011; Corsetti *et al*., 2013).

Applying this framework to advanced economies over recent decades yields a clear result. Large debt increases are episodic and concentrated in stress periods, and they are rarely organized by mechanical compounding alone. Instead, they are driven primarily by discretionary fiscal actions and balance-sheet adjustments activated during crises. The contribution of the paper is not to reject debt arithmetic, but to clarify when that arithmetic is empirically informative and when it ceases to organize realized outcomes. The findings suggest that debt sustainability should be evaluated through the lens of tail risk and crisis governance—how fiscal authorities and public balance sheets respond when shocks occur—rather than inferred from average conditions observed in normal times (Leeper and Walker, 2011; Ilzetzki *et al*., 2013).

II. Literature Review

Contemporary analysis of sovereign debt sustainability begins from the intertemporal government budget constraint but quickly moves beyond "debt level" diagnostics to the behavior of fiscal policy and the credibility of adjustment. The seminal fiscal-reaction approach formalizes sustainability as a systematic response of the primary balance to inherited debt, interpreted as evidence that policy internalizes solvency (Bohn, 1995, 1998). This empirical benchmark remains foundational in policy surveillance and academic work because it connects observed fiscal behavior to long-run feasibility without requiring a full structural model.

Subsequent research clarified that empirical sustainability assessment must confront nonstationary, persistence, and regime shifts that complicate asymptotic inference in macro time series (Arellano and Bond, 1991; Blundell and Bond, 1998; Bun and Kiviet, 2003; Judson and Owen, 1999; Roodman, 2009). At the same time, crisis-era policy debates emphasized that debt dynamics cannot be evaluated in isolation from policy institutions and expectations—including fiscal rules, independent fiscal forecasting, and monetary credibility—because these shape both market pricing and feasible adjustment paths (Alesina and Giavazzi, 2013; Alesina and Summers, 1993; Debrun *et al*., 2019).

The key limitation of reaction-function evidence is that it estimates average behavior and implicitly assumes stable mapping from debt to fiscal effort across states. Yet the largest debt increases are episodic and clustered in stress events, precisely when fiscal responses, political constraints, and market pricing may change discontinuously. This motivates approaches that treat sustainability as state-contingent and pay explicit attention to crisis identification and structural breaks (Bai and Perron, 2003; Pesaran, 2004).

A second major strand re-centered debt arithmetic through the interest–growth differential $r - g$. In low-rate environments, a negative $r - g$ can mechanically relax debt accumulation pressure, motivating arguments that high debt may be less costly than traditional "crowding out" narratives imply (Blanchard, 2019; Elmendorf and Sheiner, 2017; Mauro and Zhou, 2020). Empirically, the prevalence of long stretches of negative $r - g$ has been documented in modern datasets and synthesized in policy-adjacent analyses (Barro, 2020; Reis, 2021, 2022).

However, the literature also stresses that $r - g$ is not a sufficient statistic: (i) marginal borrowing costs can rise abruptly even when averages look benign, (ii) political and institutional shocks can reprice term premia and inflation risk, and (iii) debt valuation depends on risk, liquidity, and safe-asset status—features not captured by a single differential (Dynan, 2023; Dynan and Elmendorf, 2025; Leeper, 2023; Neveu and Schafer, 2024; Plante et al., 2025). The recent wave of work on Treasury demand, auction functioning, and long-term yields highlights that market pricing reflects both fiscal fundamentals and macro-financial equilibrium forces (Krishnamurthy and Vissing-Jorgensen, 2012; Del Negro et al., 2017; Gust and Skaperdas, 2024).

Recent debate has clarified both the usefulness and the limits of $r - g$–based reasoning. Blanchard (2019) emphasizes that when the interest–growth differential is persistently negative, debt dynamics may be mechanically stable even at elevated debt levels, shifting attention toward risk rather than solvency per se. Subsequent contributions stress, however, that $r - g$ is an equilibrium outcome rather than a policy invariant: it reflects expectations, risk premia, and institutional credibility, and can reverse abruptly in stress episodes (Reis,

2021; Rogoff, 2022). In this view, favorable historical $r - g$ realizations do not constitute a sufficient statistic for fiscal space, nor do they eliminate the relevance of credibility, inflation risk, and rollover concerns.

A parallel standard of the literature treats government liabilities as part of the economy's liquidity and collateral architecture. In these models, sovereign debt can deliver money-like services—collateral, liquidity, and safety—so equilibrium yields may be depressed even when fiscal metrics deteriorate (Angeletos et al., 2016; Farhi and Tirole, 2012; Martin and Ventura, 2012, 2018). Empirically, the convenience yield on safe government bonds and the role of "safety" in determining the natural rate reinforce the idea that debt valuation includes portfolio-equilibrium components (Krishnamurthy and Vissing-Jorgensen, 2012; Del Negro *et al*., 2017; Ferreira and Shousha, 2020; Gorton and Ordoñez, 2022).

This safe-asset perspective links sovereign yields to global structural forces—risk premia, intangible capital, market power, and the wedge between safe and risky returns—documented in macro-finance trend work (Caballero *et al*., 2017; Corrado *et al*., 2016; Farhi and Gourio, 2018; Jordà *et al*., 2019). The implication is that "debt sustainability" cannot be reduced to primary balances alone: even in the absence of default risk, debt can be repriced via changing demand for safety, inflation hedging properties, or institutional credibility.

This body of work supports this paper's central motivation: headline debt ratios are incomplete risk metrics. Once global factors and portfolio demand are incorporated, the partial correlation between debt and growth can appear economically small and statistically fragile.

A third literature emphasizes that sustainability and macro-outcomes depend on the interaction of fiscal and monetary authorities—whether the regime is closer to monetary dominance or fiscal dominance. Modern treatments of the Fiscal Theory of the Price Level and related regime frameworks show how the price level and debt valuation can adjust endogenously to reconcile government liabilities with expected surpluses, especially when nominal debt, maturity structure, and commitment constraints matter (Bassetto and Cui, 2018, 2021; Brunnermeier *et al*., 2021; Cochrane, 2023; Leeper, 1991; Sims, 2021; Woodford, 2003). Closely related work on bubbles and self-fulfilling crises highlights the possibility of multiple equilibria and rollover risk even when conventional solvency conditions appear satisfied (Hellwig and Lorenzoni, 2009; Santos and Woodford, 1997; Tirole, 1985).

Empirically, the macro consequences of high debt depend strongly on state variables—growth conditions, financial stress, and inflation dynamics. The fiscal multiplier literature documents regime dependence across recessions and expansions, and underscores how crisis policy can shift the composition of debt changes through automatic stabilizers, discretionary packages, and financial-sector interventions (Auerbach and Gorodnichenko, 2012, 2013; Blanchard and Leigh, 2013). Complementary evidence on inflation risk and sovereign premia further motivates the focus on credibility and expectations anchoring rather than debt levels alone (Hilscher *et al*., 2014; Stantcheva, 2024).

Finally, a methodological literature argues that macro identification is fragile when key variation is concentrated in rare crises and structural breaks. In such settings, parameter-heavy regression strategies risk over-interpreting limited crisis observations, while the accounting identity can serve as a low-parameter organizing framework. Event-study logic, dominance criteria, and sign-frequency evidence can be more robust than asymptotic coefficient estimates when crises are few and heterogeneous (Bai and Perron, 2003; Driscoll and Kraay, 1998; Cameron and Miller, 2015).

III. Methodology

III.I. Conceptual framework: debt dynamics as an accounting problem under rare crisis states

This paper develops an accounting-based framework to study public debt dynamics when large debt increases are rare, episodic, and concentrated in crisis states. The motivating observation is that the years that matter most for the long-run debt path—global financial crises, pandemics, banking rescues, energy shocks, and related fiscal–financial interventions—are precisely the years least amenable to standard asymptotic identification. Conventional empirical strategies, including fiscal reaction functions (Bohn-type tests), nonlinear panel regressions, and threshold or Markov-switching approaches, typically rely on (i) many crisis realizations, (ii) stable within-regime moments, or (iii) sufficient time-series length to estimate state-dependent dynamics with precision. These requirements are fragile in annual macro data because crisis episodes are few and heterogeneous, and because the mapping from fiscal flows to measured debt stocks is especially unstable when balance-sheet operations become large.

To address these constraints, the analysis adopts a deliberately low-parameter identification design grounded in the government debt identity and exploits finite-sample distributional evidence—event-study comparisons, sign-frequency restrictions, and dominance statistics—rather than coefficient-heavy dynamic estimation. The approach follows the spirit of using accounting structure to discipline inference when data are short and when the object of interest is concentrated in tail states (rather than average years). Related debt-dynamics decompositions are standard in fiscal surveillance and sustainability analysis, including practical implementations in international institutions.

Let d_t denote the gross public debt-to-GDP ratio, r_t the ex post real interest rate on government debt, g_t real GDP growth, and pb_t the primary balance-to-GDP ratio (positive for surplus). A first-order approximation to the one-period debt ratio identity is:

$$\Delta d_t \equiv d_t - d_{t-1} = \underbrace{\left(\frac{r_t - g_t}{1 + g_t}\right) d_{t-1}}_{\text{snowball term } SB_t} - pb_t + \varepsilon_t \qquad (1)$$

where ε_t is a residual wedge that captures stock–flow adjustments (SFAs) and measurement/definition discrepancies: valuation effects on existing liabilities and public financial assets, reclassifications, timing mismatches between accrual fiscal flows and recorded issuance, financial transactions not mapped into the contemporaneous primary balance, denominator effects associated with sharp nominal GDP movements, and other balance-sheet operations. A key premise—supported by crisis-period fiscal accounting in many countries—is that ε_t is not "small noise" in stress states; it is often the primary conduit through which crisis management is transmitted onto measured debt (Escolano, 2010).

Equation (1) implies a decomposition into three conceptually distinct components. Define the snowball component:

$$SB_t \equiv \frac{r_t - g_t}{1 + g_t}\, d_{t-1} \qquad (2)$$

and the primary-balance contribution (fiscal flow component):

$$PB_t \equiv -pb_t \qquad (3)$$

Then:

$$\Delta d_t = SB_t + PB_t + \varepsilon_t \qquad (4)$$

The snowball term is the familiar mechanical channel through which the interest–growth differential maps into debt accumulation—an object widely used in fiscal indicator work and operational debt arithmetic (Blanchard, 1990). The central methodological point, however, is that the empirical relevance of $r_t - g_t$ depends not on the correctness of the snowball arithmetic (which is tautologically correct given construction), but on whether $|\, SB_t \,|$ is large relative to the combined magnitude of fiscal actions and stock–flow adjustments. In crisis states, ε_t can be large and systematic—reflecting banking rescues, public guarantees called, asset purchases/sales, emergency lending facilities, and valuation/denominator effects—so the mapping from $r_t - g_t$ to realized Δd_t may break down even when the snowball term has the "correct" sign.

This framing shifts the empirical question from "estimating debt dynamics" to "characterizing which term organizes realized debt changes in the years that move the debt path." It also clarifies the paper's contribution to the post-crisis debate on whether "$r < g$" can serve as a sufficient statistic for sustainability. While a negative average interest–growth differential can relax arithmetic pressure, it need not characterize the state-contingent mechanisms through which debt actually jumps in stress periods.

III.II. Data

The analysis uses annual data for eight advanced economies—the US, UK, Japan, Germany, France, Italy, Greece, and Singapore—over 1980–2023, subject to data availability. Public debt is measured as gross general government debt relative to GDP, and fiscal balances are expressed as shares of GDP with harmonized sign conventions.

Fiscal aggregates are drawn from the IMF World Economic Outlook (WEO) and the IMF Global Debt Database. Nominal GDP and CPI inflation are taken from the WEO. Government net lending/borrowing (% of GDP) is used to construct primary balances where required. For the US, interest rates, inflation, and supplementary macroeconomic series are obtained from the Federal Reserve Bank of St. Louis FRED database; for other countries, interest-rate data are sourced from the IMF International Financial Statistics and national central banks.

Real interest rates are constructed ex post as nominal policy rates minus contemporaneous CPI inflation. These data are used to implement the standard government debt-identity decomposition and to compare debt behavior across crisis and non-crisis states.

III.III. Empirical strategy: state conditioning, sign-frequency tests, and dominance

The empirical strategy exploits the decomposition in equation (4) using three complementary components that require minimal parameter estimation.

Crisis years are defined ex-ante based on widely recognized macro-financial disruptions (*e.g.*, the Global Financial Crisis and the COVID-19 pandemic window). This avoids endogeneity that would arise from defining crises using debt outcomes. The core object is the distribution of annual debt changes Δd_t across crisis and non-crisis years, emphasizing medians and tail behavior rather than means alone.

Because the snowball component is mechanically implied by construction, a basic internal check is whether theoretical sign restrictions hold:

$$\Pr\left(SB_t > 0 \mid r_t - g_t > 0\right) \qquad (5)$$

If the decomposition is coded correctly, equation (5) should be essentially one. This check is not economically deep, but it matters for credibility: it demonstrates that any subsequent "snowball weakness" is not an artifact of sign conventions or a construction error.

Explanatory relevance: alignment and dominance in debt-increase years. To evaluate whether the snowball term actually organizes realized debt increases, the paper focuses on years when debt rises, $\Delta d_t > 0$, and computes:

$$\Pr\left(SB_t \cdot \Delta d_t > 0 \mid \Delta d_t > 0\right) \qquad (6)$$

the frequency with which the snowball term reinforces the realized debt increase. A more stringent criterion is dominance: define an indicator equal to one when the snowball component is the largest absolute contributor among the decomposition terms in debt-increase years:

$$\{\mid SB_t \mid \geq \max\left(PB_t \mid, \mid \varepsilon_t \mid\right)\} \qquad (7)$$

If debt increases are primarily snowball-driven, then Equation (6) should be high and Equation (7) should occur with nontrivial frequency. Inference is based on exact finite-sample binomial logic rather than asymptotic approximations—appropriate for short annual samples and small crisis subsamples. While the sign-test logic is standard and nonparametric, the paper's novelty is to use it systematically as an identification device for debt arithmetic under rare crisis states, rather than as an auxiliary robustness check.

Finally, to connect accounting evidence to fiscal behavior, the analysis estimates a Bohn-type fiscal reaction function (Bohn, 1998):

$$pb_t = \phi_0 + \phi_1 d_{t-1} + u_t \qquad (8)$$

with the canonical sustainability logic requiring $\phi_1 > 0$ when pb_t is measured as a surplus (or, equivalently, requiring a debt-reducing response in deficit conventions). The interpretation is explicitly reduced-form and comparative: the point is not to recover a structural policy rule, but to distinguish cases where fiscal stance appears stabilizing versus debt-deteriorating in the observed mapping from inherited debt to subsequent primary balances.

IV. Results

This section presents the paper's core empirical finding: across the studied advanced economies from 1980 to 2023, public debt dynamics are fundamentally state-dependent and cannot be summarized by the interest–growth differential $r_t - g_t$alone. The snowball component SB_t is mechanically correct as an accounting object, but it does not organize realized debt increases in the years that matter most. Large debt increases are concentrated in crisis states and are quantitatively driven by fiscal actions and stock–flow adjustments—valuation and balance-sheet operations, denominator effects, and other wedges captured by ε_t. This empirical structure persists even in countries that display stabilizing fiscal feedback in Bohn-type reaction functions. The results therefore sharpen and generalize the post-crisis caution against treating "$r < g$" as a sufficient statistic for debt sustainability, emphasizing instead the tail mechanisms that dominate realized debt changes in stress states.

IV.I. Periodicity and the distribution of debt changes: debt increases concentrate in crisis states

A first and quantitatively central regularity is that debt accumulation is not smooth. Most observations of Δd_t are small and tightly clustered, but the distribution has a pronounced right tail that becomes active in crisis states. As a result, large increases in public debt are concentrated in a small number of crisis years, which account for a disproportionate share of cumulative debt accumulation over the sample period.

The US illustrates this pattern clearly. Using the crisis coding $C_t = 1$ for 2008–2009 and 2020–2022, the median annual change in the federal debt ratio is 1.324 % of GDP in non-crisis years ($N = 38$), but 8.238 % in crisis years ($N = 5$). The mean changes are similarly separated: 1.196 pp in non-crisis years versus 7.241 pp in crisis years. A representative crisis year therefore produces a one-year debt jump roughly 6.2 times the typical non-crisis increase. The UK exhibits an almost identical quantitative signature in your event-study summary: crisis-year debt increases are roughly six times those in non-crisis years, with the same direction of shift in both median and mean.

Although crisis years represent a minority of observations, they are neither vanishingly rare nor momentary in the historical record. Major fiscal and financial crises recur with sufficient frequency and persistence that their contribution to cumulative debt dynamics is quantitatively first-order rather than exceptional. This episodic structure has two implications for inference. First, unconditional time-series summaries—"average $r - g$ is negative," "mean debt growth is moderate," or "debt drift is slow"—are not informative about the mechanisms that determine the debt path, because the debt path is disproportionately determined by tail years. Second, the years that matter most are precisely the years in which the stock–flow wedge ε_t is most likely to be large: emergency interventions, quasi-fiscal operations, financial rescues, and sharp denominator movements are concentrated in crisis states. In those states, the mapping from macro arithmetic to realized debt changes is not governed by incremental compounding, but by balance-sheet operations and policy responses that standard "snowball narratives" typically abstract from.

IV.II. Mechanical validity: the snowball term satisfies theory-implied sign restrictions in every country

Before interpreting weak snowball explanatory power as an economic result, the decomposition must pass an internal coherence check. For all eight countries studied, the snowball term satisfies the mechanical sign restriction implied by equation (2). Conditioning on $r_t - g_t > 0$, the probability that $SB_t > 0$ is 100% in every country in your sample.

This fact is not economically deep; it confirms that the snowball component is constructed correctly and behaves exactly as debt arithmetic requires. It matters because it establishes that the subsequent "snowball weakness" results are not attributable to coding errors, sign-convention mistakes, or mechanical inconsistencies. In short, the snowball term is a valid accounting object—but validity does not imply explanatory centrality.

IV.III. Conditional relevance: alignment and dominance in debt-increase years

The economically relevant question is whether the snowball term explains realized debt increases in the years when debt actually rises, *i.e.*, conditioning on $\Delta d_t > 0$. Here, the cross-country evidence is striking: snowball alignment is typically low, and in several countries, it is extremely low.

In the US, the snowball term has the same sign as Δd_t in 9 out of 30 debt-increase years (30.0%). Put differently, most US debt-increase years do not look like "$r - g$ turned unfavorable and mechanically compounded the inherited debt stock." Instead, debt frequently rises when the snowball term is not reinforcing—and sometimes when it is offsetting—implying that other components must be responsible for the realized increase.

Japan shows even weaker alignment: 7 out of 36 debt-increase years (19.4%) exhibit reinforcing snowball alignment. Germany and Italy are similar (Germany 20.0%; Italy 18.2%). Singapore and France are lower still (Singapore 11.1%; France 11.8%). These frequencies imply that in many advanced economies debt

increases occur in years where the snowball term is either (i) small, (ii) offset by fiscal and balance-sheet components, or (iii) directionally inconsistent with the realized change.

The UK and Greece are partial exceptions in that alignment is higher— 46.2% in the UK and 46.2% in Greece—but even here the implication is not snowballing dominance. Alignment near one-half means that in debt-increase years the snowball term is almost as likely to be offsetting as reinforcing. Thus, even where alignment is "higher," it does not provide a reliable organizing principle for realized debt changes.

Collectively, these conditional sign-frequency results impose a sharp correction on narratives that treat unfavorable $r - g$ realizations as the proximate driver of debt increases. Even in high-debt or stress-associated countries, debt increases are usually not "snowball-led" in the years when debt rises.

The most decisive evidence comes from comparing magnitudes. Define a dominance indicator that equals one when the snowball term is the largest absolute contributor among $| SB_t |$, $| PB_t |$, and $| \varepsilon_t |$ in debt-increase years. The result is uniform across all countries: the snowball term dominates in zero debt-increase years.

This uniformity is economically important because it implies that even when the snowball term has the "correct" sign (and it always does when $r - g > 0$), it is never the quantitatively central driver of debt increases. Large movements in debt ratios are organized by primary-balance movements and—especially in stress periods—by ε_t, the stock–flow/measurement wedge.

This dominance result is the key reason the paper can make a strong statement: the snowball mechanism is arithmetically correct but empirically non-central for the realized debt increases that shape the long-run debt path. In other words, $r - g$ may determine the direction of a mechanical component, but it is not the main driver of large and persistent increases in debt ratios.

Table 1 summarizes the four key empirical objects: (i) mechanical sign validity of the snowball component, (ii) sign alignment in debt-increase years, (iii) dominance frequency in debt-increase years, and (iv) the implied fiscal feedback in comparable primary surplus units (so positive values indicate stabilizing feedback).

Table 1. Debt dynamics and the empirical relevance of the snowball term (1980–2023)

Country	Debt-Increase Years ($\Delta d > 0$)	Pr(SB>0 | $r - g > 0$)	Pr(SB aligns | $\Delta d > 0$)	Pr(SB dominant |$\Delta d > 0$)	Fiscal Reaction (Δ surplus per +1pp debt)
United States	30	1.000 (11/11)	0.300 (9/30)	0.000 (0/18)	−0.92 pp (destabilizing)
United Kingdom	26	1.000 (24/24)	0.462 (12/26)	0.000 (0/26)	−0.99 pp (destabilizing)
Japan	36	1.000 (10/10)	0.194 (7/36)	0.000 (0/36)	+1.14 pp (stabilizing)
Germany	10	1.000 (4/4)	0.200 (2/10)	0.000 (0/10)	+0.85 pp (stabilizing)
Singapore	18	1.000 (3/3)	0.111 (2/18)	0.000 (0/18)	+1.07 pp (stabilizing)
Italy	11	1.000 (5/5)	0.182 (2/11)	0.000 (0/11)	+0.84 pp (stabilizing)
Greece	13	1.000 (9/9)	0.462 (6/13)	0.000 (0/13)	+0.90 pp (stabilizing)
France	17	1.000 (4/4)	0.118 (2/17)	0.000 (0/17)	+1.15 pp (stabilizing)

IV.IV. Fiscal feedback, institutional heterogeneity, and integrated interpretation

To connect accounting evidence to fiscal behavior, the paper estimates a Bohn-type fiscal reaction function in equation (8). In the canonical formulation, sustainability logic requires a positive response of primary surpluses to inherited debt.

The US and UK stand out as debt-deteriorating in reduced form. In the US sample where the primary balance series is available ($N = 23$), the estimated slope is strongly negative:

$$pb_t = -0.2637 - 0.9197\, d_{t-1} (R^2 = 0.903),$$

with robust $t = -12.85$ on d_{t-1}. Because d_{t-1} is in ratio units, a +1 % increase in the debt ratio (+0.01) is associated with a decline in pb_t of about 0.0092—roughly 1% of GDP more primary deficit. This is the opposite of stabilizing feedback. The UK yields a nearly identical pattern:

$$pb_t = -0.0336 - 0.9944\, d_{t-1} (R^2 = 0.9646),$$

implying about 1% of GDP deterioration in the primary balance for a +1pp increase in debt. Interpreted cautiously as reduced-form correlations rather than structural policy rules, these estimates are consistent with the view that—over the sample windows captured by the constructed series—political economy constraints and crisis responses dominate systematic consolidation in the US and UK.

In contrast, Japan, Germany, Singapore, Italy, Greece, and France exhibit stabilizing fiscal feedback once sign conventions are harmonized. For the US and UK, the fiscal reaction functions are estimated using the primary surplus convention, so that a positive coefficient corresponds to stabilizing feedback. By contrast, several of the remaining country regressions are estimated using a primary deficit convention, in which the fiscal balance variable increases with larger deficits. In those cases, a negative coefficient in the deficit regression maps mechanically into a positive response of the primary surplus to higher debt. Converting into comparable surplus units, the implied fiscal feedback (change in primary surplus for a +1pp increase in debt) is economically large: Japan +1.14pp, Germany +0.85pp, Singapore +1.07pp, Italy +0.84pp, Greece +0.90pp, and France +1.15pp.

The difference reflects only a sign convention: US and UK regressions use primary surpluses, while several other country regressions use primary deficits. Deficit-based coefficients are multiplied by −1 so that all reported effects are expressed as $\frac{\partial s_t}{\partial d_{t-1}}$.

Crucially, however, this institutional heterogeneity in fiscal feedback does not overturn the main accounting finding. Even in the stabilizing-feedback group—where Bohn-type logic appears favorable—the snowball term still never dominates the years in which debt rises. This is exactly the environment in which narratives built primarily on "average $r - g$" can mislead: the key years are crisis and balance-sheet years, and those are precisely the years in which ε_t and fiscal actions dominate short-run debt changes (Mauro and Zhou, 2020).

Taken together, the results reveal a clear hierarchy of mechanisms governing advanced-economy debt dynamics. The interest–growth differential plays a deterministic role in one limited sense: it pins down the sign of the snowball component whenever $r_t - g_t > 0$. But it does not determine the sign or magnitude of realized debt changes in the years that matter most. Debt accumulation is therefore fundamentally state-contingent.

In normal times, debt evolves gradually and remains only loosely connected to the snowball channel. In crisis states, debt changes become discontinuous: emergency fiscal measures, automatic stabilizers, financial rescues, and denominator collapses generate large Δd_t realizations that are quantitatively organized by PB_t and especially ε_t. Thus $r - g$ is not a sufficient statistic for debt sustainability when crisis states and stock–flow adjustments are admitted explicitly. In practical terms, assessments that lean heavily on "$r - g < 0$ therefore debt is safe" risk missing the tail mechanisms that actually move debt ratios. This conclusion resonates with—and provides cross-country accounting evidence supporting—the broader debate emphasizing stress scenarios, fiscal risk, and the limits of simple sufficient-statistic narratives in debt sustainability assessment.

Japan reaches the same headline conclusion as other advanced economies—debt increases are not snowball-dominated—but it does so through a distinct combination of macro structure and fiscal–balance-sheet mechanisms, making it uniquely informative for the paper's argument.

Japan shares the general "non-snowball debt increase" pattern: conditioning on $r_t - g_t > 0$, $SB_t > 0$ holds in 10/10 years, confirming mechanical coherence. Yet in years when debt rises, reinforcement is rare: only 7/36 (19.4%) debt-increase years show sign alignment between SB_t and Δd_t, and snowball dominance never occurs is (0 out of 36 years). In that respect Japan is structurally similar to Germany, Italy, France, and Singapore: "debt rose because $r - g$ was unfavorable" is not a quantitatively valid description of debt-increase years.

Where Japan differs sharply from the US and UK is the time structure of debt accumulation. The US and UK are "crisis-jump" regimes: debt increases are concentrated in a handful of stress years. Japan's debt trajectory is better characterized as persistent accumulation over long horizons rather than as rare discontinuous jumps. This matters because one might expect compounding arithmetic to loom larger in a drift regime; yet even there, the snowball term never dominates. The implication is that Japan's long-run debt increase is not primarily adverse compounding; it is sustained fiscal and balance-sheet forces operating even when the background arithmetic is benign.

Japan also differs from the US and UK in fiscal feedback. Once sign conventions are harmonized, Japan exhibits strong stabilizing fiscal response: a +1pp increase in debt is associated with roughly a +1.14pp improvement in the primary surplus (implied). On fiscal-feedback grounds, Japan therefore belongs with Germany, France, Italy, Singapore, Greece rather than with the US and UK. Yet, Japan's debt ratio rose for decades. This combination highlights a deeper point: stabilizing reduced-form fiscal feedback can coexist with long-run debt accumulation when ε_t and persistent fiscal balance-sheet choices continuously shift the debt path.

In short, Japan is the limiting case where "$r < g$" narratives most clearly fail: low interest rates may explain why debt does not explode mechanically, but they do not explain why debt rose. Japan's experience

therefore strengthens this paper's core claim that debt sustainability is state-contingent and institutionally mediated, not reducible to the snowball arithmetic alone.

V. Discussion

V.I. General Comments

This discussion advances a reinterpretation of public debt dynamics grounded in accounting structure rather than coefficient-centric estimation. The central empirical finding—that large debt increases in advanced economies are episodic, crisis-driven, and never dominated by the snowball mechanism—challenges the common practice of treating the interest–growth differential as a sufficient statistic for debt sustainability. Importantly, this conclusion does not reject the arithmetic logic of $r - g$. Instead, it clarifies the limited domain in which that logic is empirically relevant and the conditions under which it ceases to organize realized debt outcomes.

At the core of the analysis is the government debt identity in equation (1), which decomposes changes in the debt-to-GDP ratio into a mechanical snowball component, a fiscal flow component, and a residual stock–flow adjustment term capturing balance-sheet operations, valuation effects, reclassifications, timing mismatches, and denominator movements. This paper verifies that the snowball term satisfies all theory-implied sign restrictions in every country. The contribution lies in identifying which component of the identity empirically organizes realized debt changes in the years that determine the long-run debt path.

The results show that the answer is not the snowball term. Across eight advanced economies from 1980 to 2023, large increases in public debt are concentrated in a small number of stress years—global financial crises, pandemics, and major fiscal–financial interventions. In those years, the magnitude of debt changes is overwhelmingly driven by fiscal actions and stock–flow adjustments rather than by mechanical compounding. Conditioning on debt-increase years, the snowball term rarely aligns with the realized change and never dominates it in magnitude. Figure 1[1] provides a visual summary of this result, showing that the probability that the snowball component reinforces realized debt increases—conditional on $\Delta d_t > 0$—is uniformly low across advanced economies; the dashed 0.5 reference line highlights that debt increases are rarely organized by interest–growth compounding. This finding is remarkably robust across countries with very different fiscal frameworks, monetary regimes, political institutions, and degrees of financial depth, suggesting a common structural hierarchy rather than country-specific anomalies.

[1] From a theoretical perspective, the proximity of Greece and the UK to the 0.5 threshold also raises a forward-looking consideration. A sustained shift above this threshold would require not merely unfavorable interest–growth differentials, but a regime in which fiscal and balance-sheet responses are constrained or delayed, allowing mechanical compounding to operate without offset. Such a configuration would correspond to a loss of fiscal flexibility, weakened automatic stabilizers, and limited scope for balance-sheet intervention—conditions more characteristic of institutional breakdown than of normal macroeconomic adjustment. In this sense, probabilities approaching or exceeding 0.5 should be interpreted not as evidence of snowball-driven sustainability dynamics, but as warning indicators of regime change, in which standard crisis-management channels cease to function. The absence of such dominance in the historical data underscores that advanced-economy debt dynamics have remained governed by fiscal and balance-sheet responses, even under adverse $r - g$ conditions.

Figure 1. Snowball Alignment in Debt-Increase Years (1980–2023)

This evidence has direct implications for how debt sustainability has been assessed in the post-crisis literature. A large and influential body of work—both academic and policy-oriented—has emphasized the favorable arithmetic implied by persistently low interest rates (Blanchard, 2019; Blanchard *et al*., 2021; Mehrotra and Sergeyev, 2022). In this framework, a negative average $r - g$ relaxes the intertemporal budget constraint by reducing the mechanical pressure on inherited debt stocks. That logic is correct as far as it goes. However, the present results demonstrate that it does not characterize the state-contingent mechanisms through which debt actually increases. In crisis states—the years that account for the bulk of cumulative debt accumulation—the mapping from $r - g$ to Δd_t is weak or breaks down entirely because balance-sheet operations dominate.

This distinction resolves the apparent tension between optimistic $r - g$ narratives and repeated episodes of large debt accumulation observed over the past fifteen years. The interest–growth differential is best understood as a background arithmetic condition governing incremental dynamics in normal times, not as an organizing principle for tail outcomes. Formally, while $r - g$ pins down the sign of the snowball component whenever $r - g > 0$, it does not determine the sign or magnitude of realized debt changes once fiscal interventions, quasi-fiscal operations, and stock–flow adjustments are admitted explicitly. Debt sustainability therefore cannot be inferred from average compounding logic alone.

The findings also clarify the role of fiscal behavior. Classical fiscal reaction functions emphasize the response of primary balances to inherited debt, with sustainability requiring a positive feedback from debt to surplus (Bohn, 1998, 2007). In the present data, some countries exhibit stabilizing reduced-form feedback while others do not. Crucially, this institutional heterogeneity does not overturn the accounting result. Even in countries with strong stabilizing feedback—Japan, Germany, France, Italy, Greece, and Singapore—the snowball term never dominates debt increases. Stabilizing fiscal behavior governs medium-run adjustment, but it does not characterize the mechanisms through which debt jumps in crisis states. Fiscal feedback is therefore neither necessary nor sufficient for snowball-driven debt dynamics.

In this sense, the discussion reframes—but does not repudiate—the role of $r - g$. Interest–growth differentials matter, but they are not decisive. What determines long-run debt outcomes in advanced economies is not average compounding, but the interaction of fiscal policy, financial systems, and public-sector balance sheets in rare, high-impact states. Any assessment of debt sustainability that abstracts from these mechanisms risks systematic misinterpretation.

V.II. Illustrative comparison: Japan, US, and UK

A comparison of Japan, the US, and the UK helps crystallize this logic and illustrates three distinct regimes of advanced-economy debt accumulation. Japan represents the limiting case in which the shortcomings of $r - g$ narratives are most transparent. Persistently low interest rates and strong stabilizing fiscal feedback coexist

with a long-run rise in the debt ratio. The accounting evidence shows why: debt increases are not driven by adverse compounding, but by sustained fiscal commitments and balance-sheet expansions that continuously shift the debt path even when background arithmetic is benign. Low interest rates explain why Japanese debt does not explode mechanically; they do not explain why it rises.

The US illustrates a contrasting regime in which debt accumulation is dominated by discrete crisis jumps rather than gradual drift. Outside crisis periods, debt dynamics often appear consistent with conventional arithmetic narratives. Yet the years that determine the debt path—the Global Financial Crisis and the COVID-19 pandemic—are precisely those in which fiscal interventions, financial rescues, and denominator effects overwhelm the snowball mechanism. Reserve-currency status relaxes financing constraints and delays market discipline, but it does not alter the underlying accounting hierarchy that governs realized debt changes.

The UK occupies an intermediate and particularly revealing position. Like the US, UK debt accumulation is episodic; like Japan, it unfolded in an environment of historically low interest rates. The 2022 fiscal episode illustrates how rapidly credibility shocks and balance-sheet dynamics can dominate standard arithmetic, forcing large debt adjustments that are orthogonal to $r - g$. This episode is not invoked as an outlier or a cautionary tale, but as a concrete illustration of a general principle: once balance-sheet mechanisms are activated, snowball logic loses explanatory centrality regardless of the prevailing interest–growth differential.

Taken together, these cases show that there is no single "model" of advanced-economy debt dynamics. Japan's slow accumulation, the US' crisis-driven jumps, and the UK's credibility-sensitive stress episodes differ markedly in institutional detail and political economy. Yet they converge on the same accounting result. In none of these cases do realized debt increases hinge on adverse compounding. What differs across countries is not the hierarchy itself, but the institutional channels through which fiscal and balance-sheet forces are activated in rare but decisive states.

These findings imply a shift in how debt sustainability should be conceptualized, particularly in the post-pandemic environment of elevated debt ratios and heightened fiscal risk. Rather than asking whether average coefficients satisfy asymptotic conditions, the relevant question is which mechanisms dominate debt changes in the tail states that determine the debt path. From this perspective, sustainability is better understood as exposure to fiscal–financial stress scenarios than as convergence under mean arithmetic conditions (Ghosh *et al*., 2013; Mauro *et al*., 2023; IMF, 2021, 2022; BIS, 2023).

Accounting-based decompositions are particularly well suited to this task. When crisis observations are few, heterogeneous, and balance-sheet intensive, coefficient-heavy dynamic estimation is fragile and potentially misleading. By contrast, the debt identity disciplines inference without imposing strong functional-form assumptions and allows direct characterization of the mechanisms that operate in stress states. The contribution of this paper is therefore not to replace existing sustainability frameworks, but to clarify their limits and to provide a complementary lens focused explicitly on the years that matter most.

V.III. Spotlight: Japan

A forward-looking implication is that Japan's debt dynamics will be governed increasingly by the composition of adjustment in the debt identity—specifically the behavior of the primary balance component PB_t and the stock–flow adjustment term ε_t—as the global environment becomes less forgiving. The IMF's *External Sector Report 2025* (IMF, 2025) *documents* a significant widening of global current-account imbalances in 2024 and characterizes much of that widening as "excess" relative to fundamentals, signaling a shift toward more persistent cross-border spillovers transmitted through interest-rate, exchange-rate, and global-liquidity channels (IMF, 2024). In such an environment, even if Japan's background arithmetic remains benign—*i.e.*, r_t remains close to g_t—the realized debt path can be materially altered by two channels emphasized in this paper: (i) discretionary fiscal packages that sustain $PB_t < 0$, and (ii) balance-sheet-intensive operations, including credit guarantees, financial-sector backstops, and valuation or denominator effects, that load directly into ε_t. The paper's central result thus translates into a clear policy warning: the relevant margin for sustainability is the tail sensitivity of PB_t and ε_t, not the sample-average sign of $r - g$.

This logic is immediately relevant for Japan's current fiscal stance under Sanae Takaichi. Recent fiscal packages—aimed at cushioning cost-of-living pressures, supporting real wage growth, and accelerating strategic investment—mark a renewed reliance on discretionary expansion in an already high-debt environment. From the perspective of the accounting framework developed here, the central issue is not whether $r_t - g_t$ remains favorable on average, but whether current fiscal activism increases exposure to balance-sheet-driven debt jumps in future stress states. This interpretation aligns closely with the IMF's recent emphasis that high-debt economies require a credible medium-term fiscal framework**,** in which new spending is transparently offset and fiscal buffers are rebuilt, precisely because debt risks are driven by stress scenarios rather than smooth compounding. In the language of the decomposition, a credible fiscal anchor operates by preventing persistent deterioration in PB_t and by reducing the probability that crisis management is transmitted through large, systematic realizations of ε_t—including forced interventions, abrupt reclassifications, or sharp denominator collapses. The key point is therefore not austerity, but state-contingent control: limiting the balance-sheet channels that dominate debt jumps in rare,

high-impact years. Seen this way, Japan's future fiscal strategy is best evaluated not by whether $r < g$ holds on average, but by whether institutions and policy design can prevent PB_t and ε_t from becoming the dominant drivers of debt dynamics when the next stress state arrives.

VI. Conclusion

This paper reexamines advanced-economy debt dynamics through an accounting framework explicitly designed for environments in which large debt increases are rare, discontinuous, and concentrated in crisis states. The central result is clear and robust across countries and decades: although the interest–growth differential mechanically determines the sign of the snowball component, it does not organize realized debt increases in the years that shape the long-run debt path. Instead, debt accumulation in advanced economies is overwhelmingly driven by discretionary fiscal actions and stock–flow adjustments—valuation effects, financial-sector interventions, emergency lending, and denominator collapses—that are activated during periods of macro-financial stress.

This finding reframes the interpretation of post-crisis debt dynamics. Much of the recent policy debate has focused on whether persistently low real interest rates relax fiscal constraints by weakening adverse compounding. The evidence presented here suggests that this focus is misplaced. Favorable interest–growth differentials may explain why debt does not explode mechanically in tranquil periods, but they do not explain why debt rises. The decisive movements in debt ratios occur in crisis years, when balance-sheet operations and fiscal interventions dominate arithmetic compounding. In those states, the mapping from r − g to realized debt changes is weak, unstable, and often irrelevant.

This conclusion is not overturned by evidence of stabilizing fiscal behavior in reduced-form reaction functions. Several advanced economies exhibit primary-balance responses consistent with conventional sustainability logic yet still experience large and persistent debt increases. The reason is not policy inconsistency, but timing and state dependence. Fiscal feedback operates gradually, whereas crisis interventions are abrupt and large. As a result, even "responsible" fiscal regimes can accumulate substantial debt when repeated shocks require balance-sheet expansion, financial rescues, or emergency stabilization measures. Debt dynamics are therefore shaped less by average fiscal discipline than by the institutional capacity to manage tail events.

Japan provides the clearest illustration of this mechanism. Persistently low interest rates and strong domestic absorption explain why Japan's debt has not triggered market instability or explosive dynamics. But they do not explain the steady upward drift in the debt ratio over decades. That drift reflects sustained fiscal and balance-sheet choices—banking support, public investment, quasi-fiscal operations, and demographic pressures—operating even when the background interest–growth arithmetic is benign. Japan thus represents a limiting case in which "r < g" narratives are most tempting and most misleading: low rates explain debt stability, not debt accumulation.

The broader implication is forward-looking. Advanced economies today face an environment characterized by heightened macro-financial risk: geopolitical fragmentation, climate-related shocks, financial-sector vulnerabilities, and aging populations. These forces increase the likelihood that future debt trajectories will again be determined in crisis states rather than along smooth, average paths. In such an environment, sustainability assessments anchored primarily in steady-state arithmetic or average r − g comparisons risk underestimating fiscal risk. What matters most is not whether interest rates are slightly below growth on average, but how governments finance and manage balance-sheet expansions when shocks occur.

Debt sustainability, therefore, is not reducible to a sufficient statistic. It is a state-contingent, institutionally mediated outcome that depends on crisis governance, balance-sheet transparency, and the credibility of fiscal–financial coordination under stress. Accounting identities do not fail in crisis states—but economic narratives that ignore how those identities are populated in tail events do. This paper underscores the need to reorient debt analysis away from tranquil-period arithmetic and toward the mechanisms that dominate when it matters most.

VII. Acknowledgement

I gratefully acknowledge Dr. Stephen Wolff for his insightful guidance and critical feedback, which significantly enhanced the conceptual clarity and analytical rigor of this study.

VIII. Reference

1. Abel, A. B. (1992). *Can the government roll over its debt forever? Business Review*, 3–18. Federal Reserve Bank of Philadelphia. https://www.philadelphiafed.org/-/media/frbp/assets/economy/articles/business-review/1992/brnd92aa.pdf
2. Abel, A. B., Mankiw, N. G., Summers, L. H., & Zeckhauser, R. J. (1989). *Assessing dynamic efficiency: Theory and evidence.* The Review of Economic Studies, 56(1), 1–19. https://mankiw.scholars.harvard.edu/publications/assessing-dynamic-efficiency-theory-and-evidence

3. Alesina, A., & Giavazzi, F. (2013). *Introduction to fiscal policy after the financial crisis. In A. Alesina & F. Giavazzi (Eds.), Fiscal policy after the financial crisis (pp. 1–18).* University of Chicago Press. https://www.nber.org/chapters/c12631
4. Alesina, A., & Summers, L. H. (1993). *Central bank independence and macroeconomic performance: Some comparative evidence.* Journal of Money, Credit and Banking, 25(2), 151–162. https://doi.org/10.2307/2077833
5. Angeletos, G.-M., Collard, F., & Dellas, H. (2016). *Public debt as private liquidity: Optimal policy* (NBER Working Paper No. 22794). National Bureau of Economic Research. https://www.nber.org/papers/w22794
6. Arellano, M., & Bond, S. (1991). *Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations*. The Review of Economic Studies, 58(2), 277–297. https://academic.oup.com/restud/article-abstract/58/2/277/1563354
7. Auerbach, A. J., & Gorodnichenko, Y. (2012). *Measuring the output responses to fiscal policy*. American Economic Journal: Economic Policy, 4(2), 1–27. https://doi.org/10.1257/pol.4.2.1
8. Auerbach, A. J., & Gorodnichenko, Y. (2013). Fiscal multipliers in recession and expansion. In A. Alesina & F. Giavazzi (Eds.), *Fiscal policy after the financial crisis (pp. 63–98)*. University of Chicago Press.
9. Bai, J., & Perron, P. (2003). Computation and analysis of multiple structural change models. *Journal of Applied Econometrics, 18*(1), 1–22. https://doi.org/10.1002/jae.659
10. Ball, L., Elmendorf, D. W., & Mankiw, N. G. (1998). *The deficit gamble*. Journal of Money, Credit and Banking, 30(4), 699–720. https://doi.org/10.2307/2601125
11. Bank for International Settlements. (2023). *Annual economic report 2023*. https://www.bis.org/publ/arpdf/ar2023e.pdf
12. Barro, R. J. (2020). *R minus g* (NBER Working Paper No. 28002). National Bureau of Economic Research. https://www.nber.org/papers/w28002
13. Bassetto, M., & Cui, W. (2018). *The fiscal theory of the price level in a world of low interest rates*. Journal of Economic Dynamics and Control, 89, 5–22. https://doi.org/10.1016/j.jedc.2018.01.006
14. Bassetto, M., & Cui, W. (2021). *A Ramsey theory of financial distortions* (IFS Working Paper No. W21/05). Institute for Fiscal Studies. https://ifs.org.uk/publications/ramsey-theory-financial-distortions
15. Blanchard, O. (1990). *Suggestions for a new set of fiscal indicators* (OECD Economics Department Working Papers No. 79). OECD Publishing. https://doi.org/10.1787/435618162862
16. Blanchard, O. (2019). *Public debt and low interest rates*. American Economic Review, 109(4), 1197–1229. https://doi.org/10.1257/aer.109.4.1197
17. Blanchard, O., & Leigh, D. (2013). *Growth forecast errors and fiscal multipliers*. American Economic Review*,* 103(3), 117–120. https://doi.org/10.1257/aer.103.3.117
18. Blanchard, O., Leandro, A., & Zettelmeyer, J. (2021). *Redesigning EU fiscal rules: From rules to standards*. Economic Policy, 36(106), 195–236. https://doi.org/10.1093/epolic/eiab003
19. Blundell, R., & Bond, S. (1998). *Initial conditions and moment restrictions in dynamic panel data models*. Journal of Econometrics, 87(1), 115–143. https://www.sciencedirect.com/science/article/abs/pii/S0304407698000098
20. Bohn, H. (1995). *The sustainability of budget deficits in a stochastic economy*. Journal of Money, Credit and Banking, 27(1), 257–271. https://doi.org/10.2307/2077862
21. Bohn, H. (1998). *The behavior of U.S. public debt and deficits*. Quarterly Journal of Economics, 113(3), 949–963. https://doi.org/10.1162/003355398555793
22. Bohn, H. (2007). *Are stationarity and cointegration restrictions really necessary for the intertemporal budget constraint?* Journal of Monetary Economics, 54(7), 1837–1847. https://doi.org/10.1016/j.jmoneco.2006.12.012
23. Bolton, P., & Jeanne, O. (2011). *Sovereign default risk and bank fragility in financially integrated economies*. IMF Economic Review, 59(2), 162–194. https://doi.org/10.1057/imfer.2011.5
24. Brunnermeier, M. K., James, H., & Landau, J.-P. (2021). *The digitalization of money (BIS Working Paper No. 941)*. Bank for International Settlements. https://www.bis.org/publ/work941.pdf
25. Bun, M., & Kiviet, J. (2003). *On the diminishing returns of higher-order terms in asymptotic expansions of bias.* Economics Letters, 79(2), 145–152. https://papers.tinbergen.nl/02099.pdf
26. Caballero, R. J., Farhi, E., & Gourinchas, P.-O. (2017). *Rents, technical change, and risk premia*. American Economic Review, 107(5), 614–620. https://www.aeaweb.org/articles?id=10.1257/aer.p20171036
27. Cameron, A. C., & Miller, D. L. (2015). *A practitioner's guide to cluster-robust inference.* Journal of Human Resources, 50(2), 317–372. https://cameron.econ.ucdavis.edu/research/Cameron_Miller_JHR_2015_February.pdf
28. Cochrane, J. H. (2023). *The fiscal theory of the price level*. Princeton University Press.
29. Corrado, C., Haskel, J., Jona-Lasinio, C., & Iommi, M. (2016). *Intangible investment in the EU and US. In Investment and investment finance in Europe (pp. 73–102)*. European Investment Bank. https://www.eib.org/files/efs/economics_working_paper_2016_08_en.pdf

30. Corsetti, G., Kuester, K., Meier, A., & Müller, G. J. (2013). *Sovereign risk, fiscal policy, and macroeconomic stability*. Economic Journal, *123*(566), F99–F132. https://doi.org/10.1111/ecoj.12013
31. Debrun, X., Ostry, J. D., Willems, T., & Wyplosz, C. (2019). *Debt sustainability. In S. A. Abbas et al. (Eds.), Sovereign debt (pp. 151–191)*. Oxford University Press.
32. Del Negro, M., Giannone, D., Giannoni, M. P., & Tambalotti, A. (2017). *Safety, liquidity, and the natural rate of interest*. Brookings Papers on Economic Activity, 235–316. https://www.brookings.edu/articles/safety-liquidity-and-the-natural-rate-of-interest/
33. Driscoll, J. C., & Kraay, A. C. (1998). *Consistent covariance matrix estimation with spatially dependent panel data*. Review of Economics and Statistics, 80(4), 549–560. https://direct.mit.edu/rest/article-abstract/80/4/549/57104
34. Dynan, K. (2023). *High and rising U.S. federal debt. In M. S. Kearney et al. (Eds.), Building a more resilient U.S. economy (pp. 17–43)*. Aspen Institute. https://www.economicstrategygroup.org/wp-content/uploads/2023/11/Dynan_2023_Chapter.pdf
35. Elmendorf, D. W., & Sheiner, L. M. (2017*). Federal budget policy with an aging population*. Journal of Economic Perspectives, 31(3), 175–194. https://doi.org/10.1257/jep.31.3.175
36. Escolano, J. (2010). *A practical guide to public debt dynamics* (IMF Technical Notes and Manuals No. 10/02). International Monetary Fund. https://www.imf.org/external/pubs/ft/tnm/2010/tnm1002.pdf
37. Farhi, E., & Gourio, F. (2018). *Accounting for macro-finance trends*. Brookings Papers on Economic Activity, 147–250. https://www.brookings.edu/articles/accounting-for-macro-finance-trends/
38. Farhi, E., & Tirole, J. (2012). *Bubbly liquidity*. The Review of Economic Studies, 79(2), 678–706. https://doi.org/10.1093/restud/rdr039
39. Farhi, E., & Tirole, J. (2018). *Deadly embrace*. The Review of Economic Studies, 85(3), 1781–1823. https://www.jstor.org/stable/26543949
40. Ferreira, T. R. T., & Shousha, S. (2020). *Scarcity of safe assets* (International Finance Discussion Papers No. 1293). Board of Governors of the Federal Reserve System. https://doi.org/10.17016/IFDP.2020.1293
41. Ghosh, A. R., Kim, J. I., Mendoza, E. G., Ostry, J. D., & Qureshi, M. S. (2013). *Fiscal fatigue*. Economic Journal, 123(566), F4–F30. https://doi.org/10.1111/ecoj.12010
42. Gorton, G., & Metrick, A. (2012). *Regulating the shadow banking system*. Brookings Papers on Economic Activity, 261–312. https://www.brookings.edu/wp-content/uploads/2010/09/2010b_bpea_gorton.pdf
43. Gorton, G., & Ordoñez, G. (2022). *The supply and demand for safe assets*. Journal of Monetary Economics, 125, 132–147. https://www.sciencedirect.com/science/article/abs/pii/S0304393221000854
44. Gust, C., & Skaperdas, A. (2024). *Government debt, limited foresight, and longer-term interest rates* (FEDS Notes No. 2024-027). Board of Governors of the Federal Reserve System. https://doi.org/10.17016/FEDS.2024.027
45. Hall, R. E., & Sargent, T. J. (2011*). Interest rate risk and U.S. government debt dynamics*. American Economic Journal: Macroeconomics, 3(3), 192–214. https://doi.org/10.1257/mac.3.3.192
46. Hellwig, C., & Lorenzoni, G. (2009). Bubbles and self-enforcing debt. *Econometrica, 77*(4), 1137–1164. https://doi.org/10.3982/ECTA6754
47. Hilscher, J., Raviv, A., & Reis, R. (2014). *Inflating away the public debt?* NBER Working Paper No. 20339. National Bureau of Economic Research. https://www.nber.org/papers/w20339
48. Ilzetzki, E., Mendoza, E. G., & Végh, C. A. (2013). *How big are fiscal multipliers?* Journal of Monetary Economics, 60(2), 239–254. https://doi.org/10.1016/j.jmoneco.2012.10.011
49. International Monetary Fund. (2021). *Review of the debt sustainability framework for market-access countries* (Policy Paper No. 2021/003). https://doi.org/10.5089/9781513568324.007
50. International Monetary Fund. (2022). *Global debt monitor*. https://www.imf.org/-/media/files/conferences/2022/12/global-debt-monitor-2022.pdf
51. International Monetary Fund. (2024). *Japan: 2024 Article IV consultation* (Country Report No. 24/118). https://www.imf.org/-/media/files/publications/cr/2024/english/1jpnea2024010.pdf
52. International Monetary Fund. (2025). *External sector report 2025*. https://www.imf.org/en/publications/esr/issues/2025/07/22/external-sector-report-2025
53. Jordà, Ò., Schularick, M., & Taylor, A. M. (2016). *The great mortgaging: Housing finance, crises, and business cycles*. Economic Policy, 31(85), 107–152. https://doi.org/10.1093/epolic/eiv017
54. Jordà, Ò., Schularick, M., & Taylor, A. M. (2017*). Macrofinancial history and the new business cycle facts*. NBER Macroeconomics Annual, 31(1), 213–263. https://doi.org/10.1086/690241
55. Jordà, Ò., Schularick, M., & Taylor, A. M. (2019). *The rate of return on everything, 1870–2015*. Quarterly Journal of Economics, 134(3), 1225–1298. https://academic.oup.com/qje/article-abstract/134/3/1225/5435538
56. Judson, R. A., & Owen, A. L. (1999). *Estimating dynamic panel data models: A guide for macroeconomists*. Economics Letters, 65(1), 9–15. https://www.sciencedirect.com/science/article/abs/pii/S0165176599001305
57. Krishnamurthy, A., & Vissing-Jorgensen, A. (2012). *The aggregate demand for Treasury debt*. Journal of Political Economy, 120(2), 233–267. https://doi.org/10.1086/666526

58. Leeper, E. M. (1991). *Equilibria under "active" and "passive" monetary and fiscal policies*. Journal of Monetary Economics, 27(1), 129–147. https://doi.org/10.1016/0304-3932(91)90007-B
59. Leeper, E. M. (2023). *Fiscal dominance: How worried should we be?* SSRN Working Paper. http://dx.doi.org/10.2139/ssrn.4665190
60. Leeper, E. M., & Walker, T. B. (2011*). Perceptions and misperceptions of fiscal inflation*. Oxford Review of Economic Policy, 27(4), 593–610. https://www.nber.org/system/files/working_papers/w17903/w17903.pdf
61. Manski, C. F. (1995). *Identification problems in the social sciences*. Harvard University Press.
62. Martin, A., & Ventura, J. (2012). Economic growth with bubbles. *American Economic Review, 102*(6), 3033–3058. https://doi.org/10.1257/aer.102.6.3033
63. Martin, A., & Ventura, J. (2018). *The macroeconomics of rational bubbles: A user's guide*. Annual Review of Economics, 10, 505–539. https://doi.org/10.1146/annurev-economics-080217-053534
64. Mauro, P., Romeu, R., Binder, A., & Zaman, A. (2013). *A modern history of fiscal prudence and profligacy* (IMF Working Paper No. WP/13/05). International Monetary Fund. https://www.imf.org/external/pubs/ft/wp/2013/wp1305.pdf
65. Mauro, P., & Zhou, J. (2020). *$r - g < 0$: Can we sleep more soundly?* (IMF Working Paper No. WP/20/52). International Monetary Fund. https://www.imf.org/en/Publications/WP/Issues/2020/03/13/r-minus-g-negative-Can-We-Sleep-More-Soundly-49068
66. Mehrotra, N., & Sergeyev, D. (2022). *Debt sustainability in a low interest rate world*. Journal of Monetary Economics, 124, 1–19. https://doi.org/10.1016/j.jmoneco.2021.09.002
67. Neveu, A. R., & Schafer, J. (2024). *Revisiting the relationship between debt and long-term interest rates* (CBO Working Paper No. 2024-05). Congressional Budget Office. https://www.cbo.gov/system/files/2024-12/60314-DSIR-WP.pdf
68. Pesaran, M. H. (2004). *General diagnostic tests for cross-sectional dependence in panels*. Econometric Reviews, 23(2), 173–205. https://repec.iza.org/dp1240.pdf
69. Plante, M., Richter, A. W., & Zubairy, S. (2025). *Revisiting the interest rate effects of federal debt* (NBER Working Paper No. 34018). National Bureau of Economic Research. https://www.nber.org/papers/w34018
70. Reinhart, C. M., & Rogoff, K. S. (2009). *This time is different: Eight centuries of financial folly*. Princeton University Press.
71. Reinhart, C. M., & Rogoff, K. S. (2011). *From financial crash to debt crisis*. American Economic Review, 101(5), 1676–1706. https://doi.org/10.1257/aer.101.5.1676
72. Reis, R. (2021). *The constraint on public debt when $r < g$ but $g < m$* (BIS Working Paper No. 939). Bank for International Settlements. https://www.bis.org/publ/work939.htm
73. Reis, R. (2022). *Debt revenue and the sustainability of public debt*. Journal of Economic Perspectives, 36(4), 103–124. https://doi.org/10.1257/jep.36.4.103
74. Rogoff, K. S. (2022). *Emerging market sovereign debt in the aftermath of the pandemic*. Journal of Economic Perspectives, 36(4), 147–166. https://doi.org/10.1257/jep.36.4.147
75. Roodman, D. (2009). *How to do xtabond2: An introduction to difference and system GMM in Stata*. The Stata Journal, 9(1), 86–136. https://doi.org/10.1177/1536867X0900900106
76. Santos, M. S., & Woodford, M. (1997). *Rational asset pricing bubbles*. Econometrica, 65(1), 19–57. https://doi.org/10.2307/2171812
77. Sims, C. A. (2021). *Optimal fiscal and monetary policy with distorting taxes*. American Economic Journal: Macroeconomics, 13(3), 1–46. https://www.aeaweb.org/articles?id=10.1257/mac.20220245
78. Stantcheva, S. (2024). *Why do we dislike inflation?* Brookings Papers on Economic Activity. https://www.brookings.edu/wp-content/uploads/2024/03/1_Stantcheva_unembargoed.pdf
79. Tirole, J. (1985). *Asset bubbles and overlapping generations*. Econometrica, 53(6), 1499–1528. https://doi.org/10.2307/1913232
80. Woodford, M. (2003). *Interest and prices: Foundations of a theory of monetary policy*. Princeton University Press.