From Stocks to Flows: A Historical Reassessment of Debt Sustainability

Barry Eichengreen[a], Maxime Menuet[b]

[a] *University of California, Berkeley and NBER*
eichengr@econ.Berkeley.edu
[b] *Université Côte d'Azur, CNRS & SciencePo Paris, Frrance*
maxime.menuet@univ-cotedazur.fr

Abstract

This paper challenges the conventional view that fiscal sustainability depends on governments' responses to the stock of debt. Using two centuries of fiscal data (1800-2023) for the United States and a panel of advanced economies, we show that fiscal behavior is disciplined by the flow cost of debt service rather than by debt levels. Across countries, primary surpluses systematically respond to increases in debt service, while their response to the debt ratio is statistically insignificant. The short-run elasticity of fiscal effort with respect to debt service averages 0.24 in the US and 0.13 across advanced economies, exceeding unity during episodes of financial stress. We rationalize this behavior in a simple flow-based framework and derive a sustainability condition: the debt ratio remains stable when the long-run elasticity of the primary surplus with respect to debt service exceeds one. The US satisfies this condition over 1916-2023, but not over 1800-2023, indicating weaker long-term fiscal adjustment.

1. Introduction

What makes public debt sustainable? This question lies at the core of modern fiscal policy and has animated economic thought for more than a century—from the debt overhangs following the Napoleonic Wars and the World Wars, to the fiscal consolidations of the 1980s, and today's debates over unprecedented debt ratios amid rising interest rates and slowing growth (Eichengreen et al., 2021).

The prevailing analytical framework defines sustainability through an accounting identity (Debrun et al., 2020): the debt-to-GDP ratio remains stable as long as the long-run interest rate (r) does not exceed the economic growth rate (g). When $r < g$, the debt ratio converges even in the presence of primary deficits; when $r > g$, debt grows explosively unless governments raise surpluses. This "$r - g$ rule" has become the analytical cornerstone of debt sustainability assessments.[1]

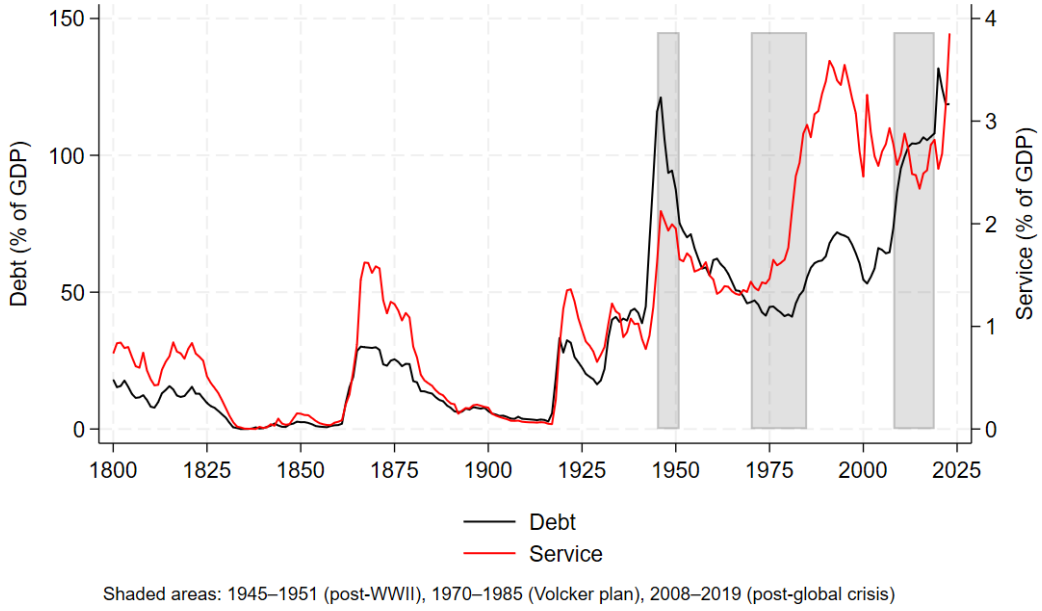
Yet this arithmetic rule says little about how governments actually behave. In practice, debt sustainability is not ensured by a mathematical inequality but by a behavioral

[1] Recent evidence shows that sovereign bond yields below the growth rate have historically been the norm rather than the exception (see, e.g., Blanchard, 2019; Mauro and Zhou, 2021).

response. Bohn (1998)'s seminal contribution formalized this intuition by showing that debt is sustainable if primary surpluses systematically rise with the debt ratio. This test has since become the empirical benchmark for assessing fiscal sustainability, and several studies confirm positive debt responses across advanced economies (e.g. Bohn, 2008; Mendoza and Ostry, 2008; Ghosh et al., 2013; Checherita-Westphal and Zyárek, 2017).

However, the behavioral foundation of this approach is incomplete. Bohn's framework assumes that fiscal authorities react to the *stock* of debt—the ratio of outstanding liabilities to GDP. Historical evidence suggests instead that governments respond to the *cost* of debt—the flow of resources needed to service it. Fiscal consolidations tend to occur when interest payments surge, not when the debt ratio peaks (see, e.g. Kremers, 1989).

Figure 1: U.S. public debt and debt service, 1800-2023



Note: Debt is gross public debt (% of GDP); debt service is interest payments (% of GDP).

Motivating evidence. The U.S. historical record illustrates this asymmetry (Figure 1). After World War II, federal debt exceeded 100% of GDP, yet rapid postwar growth and the interest-rate ceilings of the Fed-Treasury Accord kept debt service near 2% of GDP. The debt ratio fell silently through growth and inflation, not through fiscal surpluses. By contrast, during the Volcker disinflation of the early 1980s, debt levels were modest (below 40%), but real interest rates surged to double digits. Debt service doubled within five years, triggering major fiscal tightening and the introduction of the Gramm-Rudman rules. More recently, after 2008 and again during the pandemic, debt reached record highs, but debt service remained historically low, allowing persistent deficits with little market pressure. Across two centuries of U.S. data, episodes of fiscal consolidation consistently coincide with spikes in debt service, not with peaks in debt ratios.

Reframing Fiscal Sustainability. This stylized fact motivates our central claim: *governments adjust fiscal policy in response to the flow burden of debt service, not to the stock of liabilities.* We therefore propose a framework in which the primary surplus reacts to the burden of debt service—the share of income devoted to interest payments—rather than to the debt ratio itself. Fiscal adjustment thus depends directly on the realized cost of servicing debt, which captures both the level of liabilities and the financial conditions under which they are financed.

In this setting, fiscal sustainability—defined as a non-explosive debt-to-income path—can be expressed through the elasticity of the primary surplus with respect to the debt service. If this elasticity, denoted ϕ, is below one, interest payments grow faster than surpluses and debt diverges. If $\phi > 1$, fiscal effort more than offsets rising debt-service costs, ensuring convergence of the debt ratio. This yields a simple behavioral criterion for sustainability: debt remains stable only when primary surplus increases more than proportionally with the cost of servicing debt.

Empirical Strategy. We test this hypothesis by extending the standard Bohn-type fiscal reaction framework to include both debt and debt service. Specifically, we model the primary surplus as a function of its lag, the debt ratio, the debt-service ratio, and macro-financial controls. This design allows us to address two questions. On the positive side, does fiscal adjustment respond more strongly to the burden of debt service than to debt accumulation? On the normative side, is this response strong enough—*i.e.*, is the elasticity of the primary surplus with respect to debt service, ϕ, greater than one—to ensure a sustainable, non-explosive debt path?

Our empirical design combines long-run historical analysis with cross-country panel estimation. For the United States, we construct a continuous dataset covering 1800-2023, merging historical public finance series, BEA and OMB data, and recent macroeconomic indicators. This long horizon allows us to trace fiscal reactions across distinct institutional regimes—from the pre-Fed and gold standard eras to modern monetary independence. We complement baseline OLS regressions with time-series methods—vector autoregressions (VARs), state-dependent local projections, and time-varying parameter VARs —to capture dynamic responses and regime dependence. We then extend the analysis to a panel of twelve advanced economies using the IMF's *Public Finances in Modern History* database (1800-2023).

Main Results. Our findings can be summarized in three main results.

(i) Fiscal policy responds systematically to the debt service rather than to the stock of debt. Across specifications, the coefficient on debt service is positive and highly significant, while the response to the debt ratio itself is statistically insignificant. This result holds both in Bohn's original U.S. sample (1916-2023) and over the full historical span

(1800-2023). A 1% increase in debt service raises the primary surplus by about 0.6-0.65% in the modern era and roughly 0.23-0.24% over the full period, reflecting short-run adjustment elasticities. The response is state-dependent: local projection estimates show that the elasticity nearly doubles during periods of elevated risk premia, while fiscal adjustments are delayed in recessions. The finding is robust across alternative specifications and measures of debt service.

(ii) When estimated over the modern period (1916-2023), the long-run elasticity is significantly greater than one, indicating that the primary surplus increases more-than-proportionally with debt-service costs and that debt-to-income dynamics are sustainable. In contrast, using the full historical sample (1800-2023), sustainability cannot be established nor rejected, as the long-run elasticity is close to unity—suggesting that, over longer horizons, fiscal adjustment has often been insufficient to stabilize the debt ratio.

(iii) Panel estimates for twelve advanced economies over 1800-2023 confirm that fiscal policy systematically responds to the debt service rather than to the stock of debt. Across countries, the coefficient on debt service is consistently positive and significant, while the response to the debt ratio remains insignificant. Quantitatively, the short-run elasticity of the primary surplus with respect to debt service averages around 0.13 and is robust across specifications—including alternative lag structures and simultaneous-equation systems accounting for endogeneity between debt, service, and fiscal surpluses.

A cross-country comparison reveals strong heterogeneity across countries and periods. Over the long horizon (1800-2023), several countries—Canada, Italy, Norway, Spain, and the United Kingdom—exhibit long-run elasticities above unity, meeting the sustainability condition. In the modern era (1916-2023), only the United Kingdom, the United States, and Canada remain above this threshold, with the UK showing the strongest response.

Our results reveal a clear empirical regularity: governments adjust fiscal policy in response to the *flow constraint* imposed by debt service rather than to the *stock* of liabilities. Debt-service costs—not debt levels—constitute the behavioral anchor of fiscal sustainability. This reframing carries three key implications.

First, it calls for revisiting Bohn's test. The fiscal reaction condition should be formulated in terms of debt service rather than debt ratios, and sustainability should be assessed through a simple long-run elasticity test ($\phi > 1$).[2] Second, it clarifies the limits of the $r - g$ criterion: fiscal behavior responds not to expected interest-growth differentials, but to their realized impact on budgets. Third, it highlights a structural vulnerability of low-rate regimes: when debt services remain subdued, governments tend to postpone fiscal adjustment, accumulating latent risks that materialize abruptly when rates rise.

[2]This formulation also addresses the critique by Furman and Summers (2020), who emphasize that Bohn's specification conflates stocks and flows by linking a stock (debt) to a flow (GDP) in a dimensionally inconsistent way. They recommend replacing the debt-to-GDP ratio with the debt service relative to GDP, thereby restoring a proper flow–flow comparison.

Empirically, the short-run elasticity is around 0.13 in the cross-country panel, implying that for each additional dollar of interest payments, governments offset only a small fraction through higher primary surplus—leaving a persistent *fiscal effort gap* that becomes more salient when interest rates normalize.

Related literature. The first and most direct link is to the fiscal reaction framework pioneered by Bohn (1998). His approach replaced the traditional focus on debt ratio stationarity with a testable behavioral condition for solvency—now the benchmark for international institutions and a cornerstone of subsequent empirical work (Bohn, 2008; Mendoza and Ostry, 2008; Checherita-Westphal and Rother, 2012). Subsequent research has shown, however, that fiscal responses are not constant.[3] Our central contribution is that fiscal responsiveness arises not from the accumulation of liabilities, but from the realized burden of servicing them. This reformulation anchors the behavioral sustainability criteria directly in the government's budget constraint.

A second line of research emphasizes the role of financial conditions in shaping fiscal behavior. Sovereign spreads can reflect fiscal fundamentals or market expectations (Favero and Missale, 2012; Maltritz, 2012; Bahaj, 2020), while rising interest rates tighten fiscal constraints and trigger consolidation (Briotti, 2005; Guichard et al., 2007; Rawdanowicz, 2013). In this view, it is the cost of debt—not its level—that disciplines governments through market channels. This perspective underlies the snowball effect in modern institutional sustainability analysis, where the gap $r-g$ drives debt accumulation (IMF, 2013; European Comission, 2019). In this paper, rather than studying how $(r-g)$ affects debt dynamics, we examine how fiscal authorities react when the realized cost of servicing debt rises. We find that fiscal adjustment is state-dependent—most intense under elevated risk premia—thus providing the behavioral counterpart to the standard debt-sustainability arithmetic.

Our contribution unifies these two perspectives: the debt service emerges as the behavioral transmission channel linking financial conditions to fiscal effort. When interest rates rise or growth slows, higher debt service automatically elicits stronger fiscal adjustment, even in the absence of explicit normative rules.

A third strand of research links fiscal adjustment to institutional and macro-financial regimes (see Alesina et al., 1998). Fiscal reactions depend on policy mix, risk premia, or crisis regimes (Leeper, 2010; Debrun and Kinda, 2016; Burger and Marinkov, 2012). In the United States, the 1951 Fed-Treasury Accord, the Volcker disinflation, and later episodes of monetary tightening fundamentally reshaped how fiscal authorities responded to interest-rate shocks (Hall and Sargent., 2011). Our evidence adds a long-run perspective: over two centuries of U.S. data and in the historical panel, fiscal responses to debt

[3]They weaken at high debt levels (*fiscal fatigue*), vary over the business cycle, and depend on institutional settings (e.g. Ghosh et al., 2013; Checherita-Westphal and Zyárek, 2017).

service remain stable, yet become stronger during periods of market stress.[4]

Finally, our paper connects with the macro-historical literature documenting the evolution of fiscal regimes and debt sustainability over the long run (Reinhart and Rogoff, 2010; Jordà et al., 2017; Eichengreen et al., 2019; Stockhammer and Gouzoulis, 2023). We complement this body of work by revealing a persistent behavioral regularity across regimes: fiscal policy follows the flow constraint of debt service, not the stock of liabilities.

The paper proceeds as follows. Section 2 introduces the conceptual framework that motivates our empirical approach. Section 3 presents the empirical strategy and provides evidence on the responsiveness of the U.S. primary surplus. Section 4 explores the state-dependent nature of this response. Section 5 extends the analysis to a panel of advanced economies. Finally, Section 6 concludes.

2. The framework

To fix ideas and guide the empirical analysis, consider the government's flow budget constraint in continuous time:

$$\dot{b}(t) = (r - g)\, b(t) - s(t), \tag{1}$$

where a dot denotes a time derivative, $b(t)$ is the real debt-to-GDP ratio, $s(t)$ the primary surplus-to-GDP ratio, r the real interest rate, and g the GDP growth rate. For simplicity, r and g are taken as constants representing their long-run equilibrium values. Fiscal sustainability is defined as a debt path that remains bounded over time (i.e. $\sup_t b(t) < \infty$).

A stock-based fiscal rule. Bohn (1998) proposed a behavioral test based on a linear response of the primary surplus to the debt ratio, say $s(t) = \psi\, b(t) - \alpha$, where $\psi > 0$ measures fiscal responsiveness and α captures non-systematic pressures. Substituting into (1) gives:

$$\dot{b}(t) = (r - g - \psi)\, b(t) + \alpha. \tag{2}$$

Debt follows a stable (non-explosive) path if and only if $\psi > r - g$. When $r < g$, any positive response suffices; when $r > g$, stronger adjustment is required to offset the snowball effect.[5] While this rule is now the empirical benchmark, it faces two limitations. First, governments respond not to the *stock* of debt but to its *servicing cost*. Historically, fiscal consolidations coincide with surges in interest payments, not peaks in debt

[4] This pattern is consistent with state-dependent fiscal rules (see, e.g., Kremers, 1989; Debrun and Kinda, 2016; Menuet et al., 2024).

[5] Formally, a positive response $\psi > 0$ satisfies the standard no-Ponzi condition, $\lim_{t\to\infty} B(t)e^{-rt} = 0$, where $B(t)$ denotes the level of debt—often referred to as the solvency condition. By contrast, *stability* of the debt-to-GDP ratio requires that the fiscal response exceed a positive critical threshold, as shown in general-equilibrium settings (e.g. Collignon, 2012; Ghosh et al., 2013; Menuet et al., 2024).

ratios. Second, the stability condition depends on the gap $r - g$, which is uncertain and time-varying, making the sustainability condition $\psi > r - g$ difficult to assess ex ante and fragile to macro-financial shocks.

A flow-based fiscal rule. As we will see, empirical evidence indicates that fiscal adjustment responds mainly to the flow burden of debt service—the share of GDP devoted to interest payments, $r\,b(t)$—rather than to the debt stock $b(t)$ itself. We therefore propose a behavioral rule in which the primary surplus depends on the debt-service ratio, namely $s(t) = f(r\,b(t))$, where $f(\cdot)$ is increasing, with elasticity $\phi(rb) := \frac{rb\,f'(rb)}{f(rb)}$.

From (1), a steady state, denoted by b^*, satisfies

$$(r - g)\,b^* = f(rb^*). \tag{3}$$

As usual, a positive steady-state debt ratio ($b^* > 0$) requires a primary surplus when $r > g$, and a primary deficit in the opposite $g > r$. Linearizing the dynamics around b^*, stability requires $r - g < r\,f'(rb^*)$, meaning that fiscal effort must rise fast enough to offset the snowball effect. Using the steady-state relation (3), this can be rewritten as

$$f(rb^*) < rb^* f'(rb^*) \quad \Leftrightarrow \quad \phi(rb^*) > 1.$$

The debt ratio converges to a finite steady state if and only if the elasticity of the primary surplus with respect to debt service exceeds unity. Intuitively, when interest costs rise, fiscal effort must increase more than proportionally to prevent debt acceleration. The condition $\phi(\cdot) > 1$ thus defines a clear behavioral threshold for sustainability. A tractable special case assumes constant elasticity:

$$s(t) = \kappa[r\,b(t)]^{\phi}, \quad \kappa > 0. \tag{4}$$

Relative to the Bohn's stock-based rule, this flow-based formulation offers two advantages. First, it is state-contingent: -fiscal adjustment intensifies precisely when debt becomes costlier to service. Second, it yields a simpler criterion: sustainability depends solely on the elasticity ϕ, which can be estimated with standard econometric methods, not on the uncertain and time-varying gap $(r - g)$,

Taking log of (4) yields:

$$\log s(t) = \text{const.} + \phi\,\log[r\,b(t)]. \tag{5}$$

The empircal analysis that follows tests two propositions derived from this framework. On the positive side, fiscal policy should respond more strongly to the debt service than to the stock of debt, consistent with our flow-based rule (5). On the normative side, the magnitude of this response should be large enough—specifically, $\phi > 1$—to ensure that debt dynamics remain non-explosive.

3. Evidence for the United States

We begin with the United States, the benchmark case originally examined by Bohn (1998). Estimating Eq. (5) on U.S. data provides a natural starting point to evaluate whether fiscal behavior conforms to the flow-based specification proposed above.

Empirical design. We extend the standard fiscal reaction function by explicitly incorporating the debt-service component:

$$\log PS_t = \alpha + \xi \log PS_{t-1} + \beta \log Debt_t + \gamma \log Service_t + v'\mathbf{X}_{t-1} + \varepsilon_t, \tag{6}$$

where PS_t denotes the primary surplus (as a share of GDP), $Debt_t$ the public debt (as a share of GDP), $Service_t$ interest payments (as a share of GDP), $\mathbf{X}_{t-1}$ a vector of other determinants of the primary surplus, and ε_t an error term. .

The coefficient γ measures the short-run elasticity of the primary surplus with respect to the debt service, while ξ captures persistence in fiscal behavior. The corresponding long-run elasticity is computed as $\phi = \gamma/(1-\xi)$, which provides a direct empirical diagnostic of the sustainability condition derived in the theoretical framework.

Eq. (6) includes the lagged primary surplus to capture persistence in fiscal policy decisions. Following the literature on fiscal reaction functions (e.g., Bohn, 2008; Mendoza and Ostry, 2008; Ghosh et al., 2013; Debrun and Kinda, 2016), we include in the control vector $\mathbf{X}_{t-1}$, the lagged of output gap to account for cyclical effects, of inflation rate to capture the impact of price dynamics, of trade openness to control for the external stance, and of the sovereign risk premium on U.S. government bonds to proxy for perceived fiscal risk. We also include a set of dummy variables to account for institutional and historical events: the independence regime of the Federal Reserve (post-1951 Accord), the 2008 Global Financial Crisis, and the two World Wars.[6]

Identification. The coefficient on $Service_t$ may be biased if interest payments respond endogenously to contemporaneous fiscal decisions or if omitted shocks jointly affect fiscal effort and borrowing costs. We address these concerns in several complementary ways. First, the inclusion of PS_{t-1} and lagged macro controls $\mathbf{X}_{t-1}$ helps capture policy persistence and remove short-term cyclical co-movements. Second, event dummies (wars and crises) absorb structural breaks in fiscal regimes and financing conditions. Third, as a robustness check, we replace $Service_t$ by its lagged value $Service_{t-1}$ to ensure that the estimated reaction reflects responses to observed, not contemporaneous, interest costs. Fourth, we complement baseline OLS estimates with dynamic specifications—vector autoregressions (VAR), time-varying parameter VARs (TVP-VAR), and state-dependent

[6]Variable definitions, data sources, and summary statistics are reported in Tables (A.6)-(A.7)-(A.8) in Appendix A. Figure A.7 illustrates the evolution of the debt-service ratio and the long-term interest rate over 1800-2023.

local projections—to trace the dynamic response of fiscal policy to changes in debt service. Finally, we extend the analysis in Section 5 to a cross-country panel using dynamic least squares dummy variable (LSDV) estimators with country and year fixed effects, as well as heterogeneous-coefficient Mean Group estimators and simultaneous 3SLS systems to address potential endogeneity and common global shocks.

3.1. Benchmark Evidence: 1916-2023

To compare our results with those of Bohn (1998), we adopt his sample starting date (1916) and extend the period through 2023. Table 1 presents the OLS estimates. Specification (1) controls for the lagged output gap, inflation, and a dummy for the 2008 financial crisis. Specification (2) additionally includes a dummy for Fed independence, while Specification (3) further adds the lagged value of trade openness.

Table 1: Baseline – The response of the primary surplus in the United States (1916-2023)

	(1)	(1')	(2)	(2')	(3)	(3')
Variables	Primary surplus					
Primary surplus (t-1)	0.787***	0.776***	0.767***	0.762***	0.775***	0.776***
	(0.080)	(0.080)	(0.082)	(0.082)	(0.085)	(0.084)
Debt	-0.538	-0.519	-0.592	-0.558	-0.877	-0.608
	(0.439)	(0.396)	(0.425)	(0.383)	(0.597)	(0.450)
Service	0.653**		0.598**		0.833**	
	(0.328)		(0.359)		(0.419)	
Service (t-1)		0.612**		0.564*		0.687**
		(0.268)		(0.303)		(0.321)
Output gap (t-1)	0.034	0.042	0.032	0.039	0.018	0.003
	(0.057)	(0.056)	(0.057)	(0.057)	(0.076)	(0.069)
Inflation (t-1)	-0.003	0.009	-0.005	0.007	-0.001	0.019
	(0.027)	(0.029)	(0.028)	(0.031)	(0.037)	(0.041)
FED indep.			0.233	0.191	0.518	0.279
			(0.288)	(0.291)	(0.481)	(0.494)
Trade openness (t-1)					-10.51	-8.971
					(6.853)	(6.562)
2008 crisis	-2.134***	-2.172***	-2.147***	-2.179***	-1.708***	-1.803***
	(0.143)	(0.144)	(0.144)	(0.146)	(0.316)	(0.311)
Constant	1.674	1.589	1.747	1.634	3.048	2.150
	(1.547)	(1.404)	(1.535)	(1.392)	(2.191)	(1.694)
Observations	108	108	108	108	83	83
Wars					✓	✓

Notes: Numbers in parentheses are robust standard errors. The errors are not auto-correlated according to Portmanteau tests. Primary surplus, Debt, Service and Output gap are in log. The estimates cover the period from 1916 to 2023. *, ** and *** denote significance at 10%, 5% and 1% levels.

Across all specifications, the inclusion of debt service yields a positive and statistically significant coefficient, whereas the coefficient on debt becomes insignificant at conventional levels. Hence fiscal adjustment responds systematically to the cost of servicing debt, not to the debt stock.

Across specifications (1)-(2), a 1% increase in debt service is associated with a rise in the primary surplus of about 0.6-0.65%. The estimated response becomes larger—around 0.8-0.83%—when controlling for the two World Wars, reflecting the fact that governments are generally less inclined to implement fiscal corrections during wartime. Including lagged debt service ($Service_{t-1}$) yields qualitatively similar results (columns 1'-2'-3'), ruling out mechanical simultaneity. Quantitatively, the estimated elasticities are smaller (between 0.56 and 0.68), suggesting that governments adjust their fiscal stance more strongly to current increases in debt-servicing costs, and less so to past increases.

Finally, when running a traditional Bohn-type specification by omitting the debt service, the debt ratio is positive and significant, and its value is in line with prior studies (see Table A.9 in Appendix A). This confirms that the insignificance of $Debt_t$ in our main specification (6) is not driven by period choice but by the inclusion of the debt service.

3.2. Extending the Horizon: 1800-2023

We next extend the analysis to the full historical period from 1800 to 2023. Table 2 reports OLS estimates. The key finding remains robust: the coefficient on the debt service is positive and statistically significant, around 0.23-0.24, whereas the coefficient on the debt ratio remains insignificant across all specifications. This confirms that U.S. fiscal policy has historically responded to the cost of debt rather than to its stock.

The magnitude of the fiscal response is smaller than in the post-1916 sample, reflecting both the greater heterogeneity of fiscal regimes and the episodes of financial repression that kept interest payments low despite large debt stocks (see Roubini and Sala-i-Martin, 1992). In addition, the lower responsiveness before the twentieth century likely mirrors the more limited fiscal capacity and underdeveloped domestic bond markets of early states. Consistent with the results for the post-1916 period, including lagged debt service yields qualitative similar estimates (columns 4'-5'-6'), with smaller estimated elasticities.

These baseline results establish three central findings. First, fiscal adjustment in the United States responds systematically and significantly to the cost of servicing debt rather than to the debt stock itself. Second, this service-based response is stable over two centuries of data (1800-2023): governments consistently adjust primary surpluses when interest payments rise, while the debt ratio plays no independent role. Third, the magnitude of this adjustment is meaningful. A 1% increase in debt service raises the primary surplus by about 0.6-0.65% in the post-WWI period and by roughly 0.23-0.24% over 1800-2023.

Table 2: Baseline – The response of the primary surplus in the United States (1800-2023)

Variables	(4)	(4')	(5)	(5')	(6)	(6')
	Primary surplus					
Primary surplus (t-1)	0.781***	0.782***	0.793***	0.786***	0.786***	0.779***
	(0.059)	(0.060)	(0.071)	(0.073)	(0.073)	(0.075)
Debt	-0.188	-0.110	-0.180	-0.126	-0.181	-0.127
	(0.115)	(0.076)	(0.111)	(0.078)	(0.109)	(0.077)
Service	0.230**		0.244**		0.238*	
	(0.123)		(0.124)		(0.132)	
Service (t-1)		0.142*		0.184**		0.180*
		(0.087)		(0.094)		(0.101)
Output gap (t-1)	0.057	0.059	0.037	0.036	0.033	0.032
	(0.043)	(0.043)	(0.048)	(0.046)	(0.047)	(0.046)
Inflation (t-1)	-0.022	-0.022	-0.020	-0.019	-0.022	-0.021
	(0.014)	(0.014)	(0.017)	(0.017)	(0.019)	(0.019)
2008 crisis	-2.185***	-2.182***	-2.106***	-2.147***	-2.081***	-2.125***
	(0.119)	(0.120)	(0.277)	(0.280)	(0.294)	(0.301)
Trade openness (t-1)			-1.764	-1.066	-2.828	-1.934
			(4.874)	(4.817)	(6.278)	(6.361)
FED indep.					0.080	0.061
					(0.311)	(0.312)
Constant	0.675*	0.415	0.741	0.529	0.762	0.552
	(0.391)	(0.262)	(0.467)	(0.347)	(0.466)	(0.350)
Observations	223	223	168	168	168	168
Wars	✓	✓			✓	✓

Notes: Numbers in parentheses are robust standard errors. The errors are not auto-correlated according to Portmanteau tests. Primary surplus, Debt, Service and Output gap are in log. The estimates cover the period from 1800 to 2023. The errors are not auto-correlated according to Portmanteau tests. *, ** and *** denote significance at 10%, 5% and 1% levels.

3.3. Sustainability diagnostic

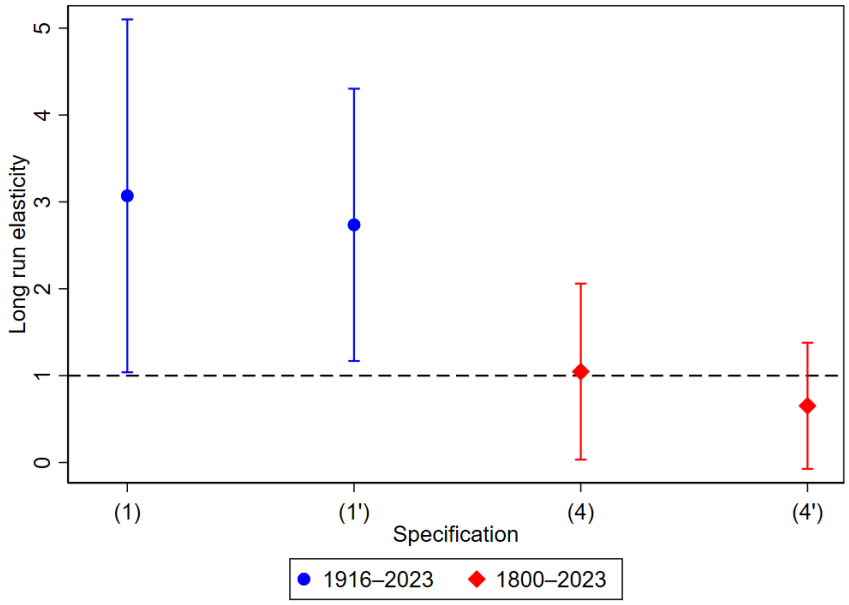
Our theoretical framework provides a simple diagnostic rule for fiscal sustainability: if the long-run elasticity $\phi = \gamma/(1-\xi)$ exceeds unity, fiscal policy reacts more than proportionally to changes in debt service. In this case, debt dynamics converge and remain sustainable under our service-based rule.

Figure 2 reports the 95% confidence intervals of the estimated long-run elasticities, based on specifications (1) and (1') in Table 1 for the 1916-2023 period, and (4) and (4') in Table 2 for the full 1800-2023 sample.

In the recent period, the long-run elasticity is robustly and significantly above one, indicating that public debt is sustainable in the sense of a stable debt-to-GDP ratio. Over the extended historical horizon, however, sustainability cannot be firmly established: the long-run elasticity is statistically indistinguishable from one. This suggests that

fiscal responsiveness was weaker in earlier periods, making long-term sustainability more uncertain.

Figure 2: Long-run elasticity of the primary surplus to debt Service—OLS estimates (United States)



Notes: The figure displays the 95% confidence intervals of the long-run elasticity, computed as $\gamma/(1-\zeta)$ from specification (6). Estimates (1) and (1') correspond to Table 1 (1926-2023), while estimates (4) and (4') correspond to Table 2 (1800-2023).

These findings open several questions about the mechanisms and stability of this reaction. Does the strength of fiscal adjustment depend on financial conditions—tightening when risk premia are high or interest costs spike? Does the response vary across phases of the business cycle, strengthening during recessions or fiscal stress episodes? And how persistent and stable is this behavioral pattern across historical regimes marked by different monetary and institutional frameworks?

4. Extensions and Robustness

This section extends the analysis along several complementary dimensions. We begin by testing the robustness to an alternative measure of debt service, replacing the realized interest burden with a yield-based proxy that captures the hypothetical contemporaneous refinancing cost at market rates. Next, we investigate whether fiscal responses intensify when market risk premia are high, consistent with a state-contingent adjustment mechanism. We then estimate state-dependent local projections (Jordà, 2005) to assess how the response of the primary surplus to debt-service shocks varies across financial and macroeconomic regimes—specifically, between periods of high and low risk premia, and between recessions and expansions. Subsequently, we estimate a VAR model to characterize the

dynamic propagation of shocks to debt service and debt stocks on the primary surplus. Finally, we implement a Time-Varying Parameter VAR (TVP-VAR) à la Primiceri (2005) to evaluate how the strength and persistence of the fiscal reaction have evolved over time.

4.1. Alternative proxy: yields versus realized service.

As a robustness check, we replace the effective interest burden (rB_t) with a yield-based proxy, defined as the 10-year Treasury yield multiplied by the debt-to-GDP ratio, capturing the hypothetical contemporaneous cost of refinancing at market rates.

Results in Table A.10 (in Appendix A) show that this yield-based measure is insignificant across all specifications, while other coefficients remain stable. This suggests that fiscal policy responds to the realized cost of servicing debt rather than to short-term fluctuations in market interest rates. Conceptually, the 10-year yield reflects future borrowing conditions, whereas the debt-service ratio captures actual interest expenditures on liabilities—the component that directly enters the government's budget constraint. Given the long average maturity and fixed-rate structure of U.S. public debt, changes in yields translate into fiscal costs only gradually. Consequently, what drives fiscal adjustment is not the market price of debt, but the effective fiscal pressure arising from interest payments.

4.2. Does fiscal reaction strengthen when financial conditions tighten?

Interaction term Service × Risk premium. We start by exploring whether the responsiveness of fiscal policy to debt service increases when market risk premia are high. In periods of financial stress, rising premia amplify the cost of refinancing and are likely to trigger stronger fiscal adjustments, consistent with the idea that fiscal discipline is endogenous to the cost of market financing. To test this mechanism, we augment (6) with the interaction term $Service_t \times RP_t$, where RP_t denotes the risk premium on U.S. long-term government bonds (the spread between 10-year Treasury yields and a risk-free benchmark).

Table 3 reports the results over the period 1928-2023. The lagged interaction between the debt service and the risk premium is positive and highly significant. This implies that fiscal authorities tighten policy more aggressively when financing conditions deteriorate. A one-standard deviation increase in the risk premium approximately doubles the short-run elasticity.

This result remains robust when controlling for major historical shocks such as World War II, the 2008 global financial crisis, and the 2020 pandemic episode. Columns (4)-(6) further include a dummy for NBER recessions—periods identified by the NBER as cyclical contractions in U.S. economic activity. The interaction term remains positive and significant, while the recession dummy itself enters with a strong negative coefficient, confirming that fiscal surplus systematically deteriorate during downturns but that governments react more forcefully to debt-service pressures in those contexts. In contrast, the direct effect of the risk premium itself is insignificant, suggesting that it is

the combination of higher interest costs and tighter market conditions that triggers fiscal consolidation.

Table 3: Extension – The response of the primary surplus and financial conditions in the United States

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Primary surplus					
Primary surplus (t-1)	0.837***	0.790***	0.773***	0.774***	0.748***	0.730***
	(0.056)	(0.073)	(0.075)	(0.075)	(0.092)	(0.092)
Service (t-1)	0.318	0.006	0.134	-0.251	0.535	0.243
	(0.232)	(0.289)	(0.281)	(0.308)	(0.463)	(0.444)
Service x RP (t-1)	1.878*	1.838*	1.995**	2.148**	2.247**	2.504***
	(1.064)	(0.960)	(0.959)	(1.094)	(0.901)	(0.920)
Risk Premium (t-1)	0.069	0.006	-0.029	-0.618	-0.229	-1.104
	(0.773)	(0.709)	(0.694)	(0.867)	(0.700)	(0.718)
Output gap (t-1)	0.023	0.006	0.039	-0.069	0.062	-0.067
	(0.049)	(0.049)	(0.045)	(0.076)	(0.079)	(0.069)
FED indep.		0.611	0.605	0.589	0.896*	0.877*
		(0.382)	(0.385)	(0.395)	(0.490)	(0.471)
NBER recessions (t-1)				-0.797***		-0.980***
				(0.224)		(0.239)
2001 crisis			0.281			
			(0.306)			
2008 crisis			-1.953***		-1.835***	
			(0.157)		(0.250)	
2020 crisis			-2.132***			
			(0.230)			
Trade openness (t-1)					-8.815	-10.43
					(8.533)	(8.728)
Constant	-0.454**	-0.764***	-0.818***	-0.284	-0.821**	-0.155
	(0.197)	(0.265)	(0.269)	(0.315)	(0.346)	(0.393)
Observations	95	95	95	95	70	70
WWII				✓		

Notes: Numbers in parentheses are robust standard errors. The errors are not auto-correlated according to Portmanteau tests. Primary surplus, Debt, Service and Output gap are in log. The estimates cover the period from 1928 to 2023. The errors are not auto-correlated according to Portmanteau tests. *, ** and *** denote significance at 10%, 5% and 1% levels.

This pattern supports the interpretation of the service-based rule as a self-stabilizing mechanism—one that endogenously tightens fiscal discipline when market financing conditions worsen and debt sustainability risks intensify.

State-dependent local projections. We next assess the dynamic response of the primary surplus to shocks in the debt service under different states of financial and economic conditions, using the local projection approach of Jordà (2005). Formally, we

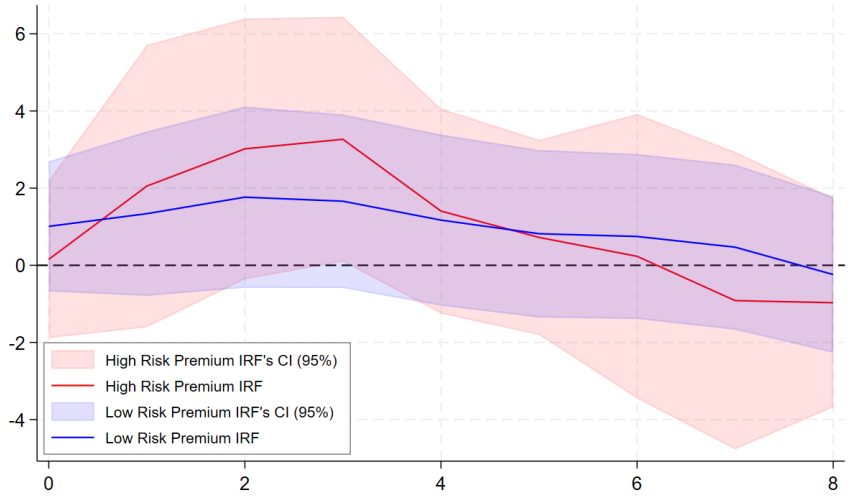
estimate:

$$\log PS_{t+h} = \xi \log PS_{t-1} + 1[RP_{t-1} > RPQ3_{t-1}](\gamma^h_{high} \log Service_{t-1}) + 1[RP_{t-1} < RPQ3_{t-1}](\gamma^h_{low} \log Service_{t-1}) + \mathbf{X}_{t-1}\nu^h + \varepsilon_t, \quad (7)$$

where h indexes the horizon after the shock, and the high (low) financial stress regime is defined as periods when the risk premium is above (below) its 75th percentile. $\mathbf{X}_{t-1}$ includes the debt ratio, inflation, output gap, and a dummy for NBER recessions, which mark official U.S. downturns.

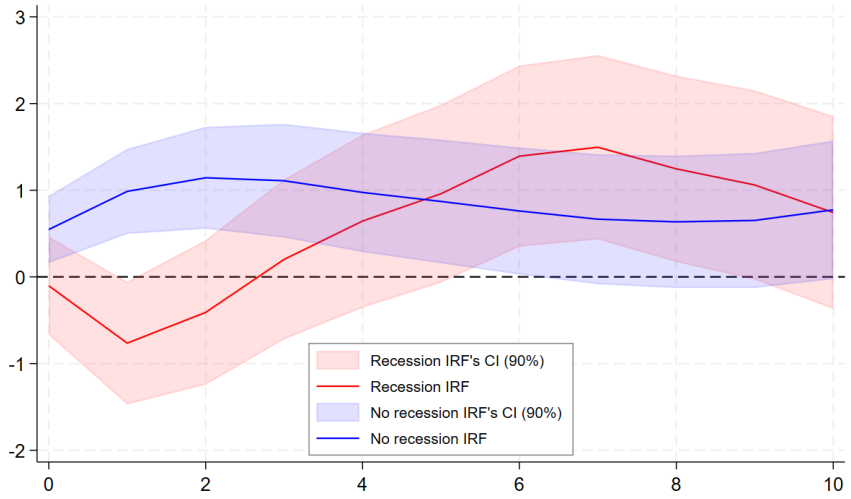
Figure 2 displays the estimated impulse responses. When the risk premium is low, a shock to the debt service elicits no significant fiscal response. Conversely, under high-risk-premium regimes, a one-standard-deviation increase in the debt-service ratio leads to a rise of approximately 0.03% in the primary surplus after three years, indicating that fiscal adjustment intensifies markedly when financial conditions tighten. A similar pattern arises when conditioning on the business cycle using NBER recession dates (Figure 3). During non-recession periods, fiscal surplus reacts immediately—within the first five years—when the debt service rises. By contrast, in recessions, the adjustment is delayed by up to six years, suggesting that corrective measures are postponed when economic conditions are weak. This feature is consistent with countercyclical fiscal behavior: governments temporarily accommodate higher financing costs during downturns, before undertaking stronger adjustment once economic conditions improve.

Figure 3: State-dependent response to a debt-service shock (financial stress regimes)



Notes: High/low risk-premium regimes are defined as above/below the 75th percentile. State dependence measured with a dummy for high/low risk premium. The shock applies to the debt service.

Figure 4: State-dependent response to a debt-service shock (recession periods)



Notes: State dependence is measured with an NBER recession dummy. The shock applies to the debt service.

These results indicate that fiscal responsiveness to debt-service pressures is state-dependent: it is stronger when risk premia rise sharply, and delayed in recession periods. To next examine the persistence, timing, and historical evolution of this service-based adjustment mechanism, the following subsection develops a multivariate time-series framework using a VAR and Time-Varying Parameter VAR (TVP-VAR) model over the full U.S. sample from 1800 to 2023.

4.3. Dynamic analysis: VAR and time-varying responses

A dynamic approach is important for two reasons. First, it allows us to distinguish between short-term and medium-term fiscal responses, capturing the delayed adjustments that are typical of fiscal processes, as we have shown. Second, it provides a robustness check against potential simultaneity biases that may arise in static OLS regressions.

Model specification. We estimate a VAR model linking the primary surplus, debt variables, and the business cycle:

$$\begin{bmatrix} \log PS_t \\ \log D_t \\ \log \tilde{Y}_t \end{bmatrix} = B(L) \begin{bmatrix} \log PS_t \\ \log D_t \\ \log \tilde{Y}_t \end{bmatrix} + u_t, \tag{8}$$

where D_t is alternately the debt service ($Service_t$) or the debt-to-GDP ratio ($Debt_t$), and $\tilde{Y}_t$ represents the output gap, capturing cyclical conditions. All variables are expressed in logarithms relative to GDP. The lag polynomial $B(L)$ captures dynamic dependencies, and u_t represents the innovation vector. We also control for Fed independence and Wars.

Preliminary diagnostics. We assess the time-series properties of all variables. Phillips-Perron (PP), Augmented Dickey-Fuller (ADF), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests confirm stationarity for the log of primary surplus, the debt ratio, the debt service, and the output gap (see Table A.11 in Appendix A). This ensures that the VAR can be estimated in levels without spurious dynamics.[7]

Impulse response analysis. Figures 4 and 5 display the estimated impulse response functions (IRFs) of the primary surplus to one-standard-deviation shocks in the debt service and the debt ratio, respectively. The comparison provides a direct dynamic test of whether fiscal adjustments are more responsive to the cost or to the stock of debt.

Figure 5: Impulse response of the primary surplus to a debt-service shock

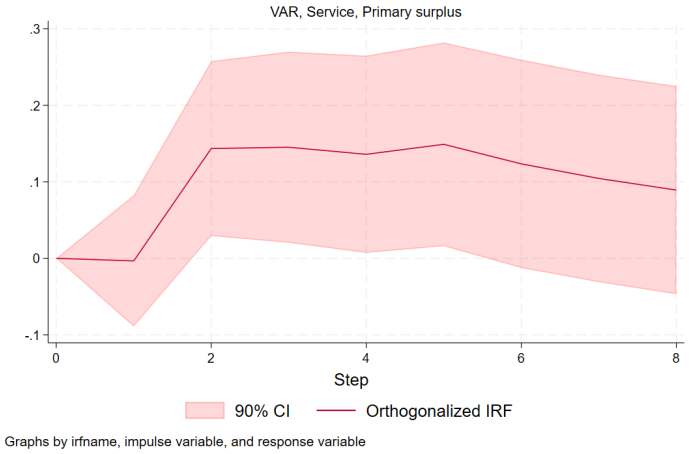


Figure 6: Impulse response of the primary surplus to a debt shock



[7]The ADF and PP tests examine the null of a unit root against stationarity, whereas KPSS tests the null of stationarity. The results consistently reject the presence of a unit root in all series.

A positive shock to the debt service induces a significant and persistent increase in the primary surplus, beginning approximately two years after the shock. Quantitatively, a one-standard-deviation increase in the debt service raises the primary surplus by around 0.14 percentage points after two years. Scaling the response, a 1% increase in the debt service corresponds to an adjustment of roughly 0.04% of GDP in the primary surplus. By contrast, shocks to the debt ratio produce no significant effect, supporting our claim that fiscal behavior is mainly driven by the cost of servicing debt rather than by the outstanding stock. Granger-causality tests confirm that causality runs from the debt service to the primary surplus, not the reverse (see Tables A.12 and A.13 in Appendix A).

Time variation in fiscal responses. To assess whether this reaction mechanism is stable across historical regimes, we estimate a time-varying parameter VAR (TVP-VAR) following Primiceri (2005):

$$\begin{bmatrix} \log PS_t \\ \log D_t \\ \log \tilde{Y}_t \end{bmatrix} = B_t(L) \begin{bmatrix} \log PS_t \\ \log D_t \\ \log \tilde{Y}_t \end{bmatrix} + u_t. \tag{9}$$

This specification allows the coefficients and shock variances to evolve smoothly over time, capturing structural changes in fiscal behavior. The analysis covers the full sample from 1800 to 2023, encompassing three major transformations of the U.S. fiscal regime: the pre-modern era (before 1900), the post-World War II reconstruction (1940-1970), and the modern fiscal-monetary regime (post-1970).

Figure 7: Time-varying response of the primary surplus to debt-service shocks (1800-2023)

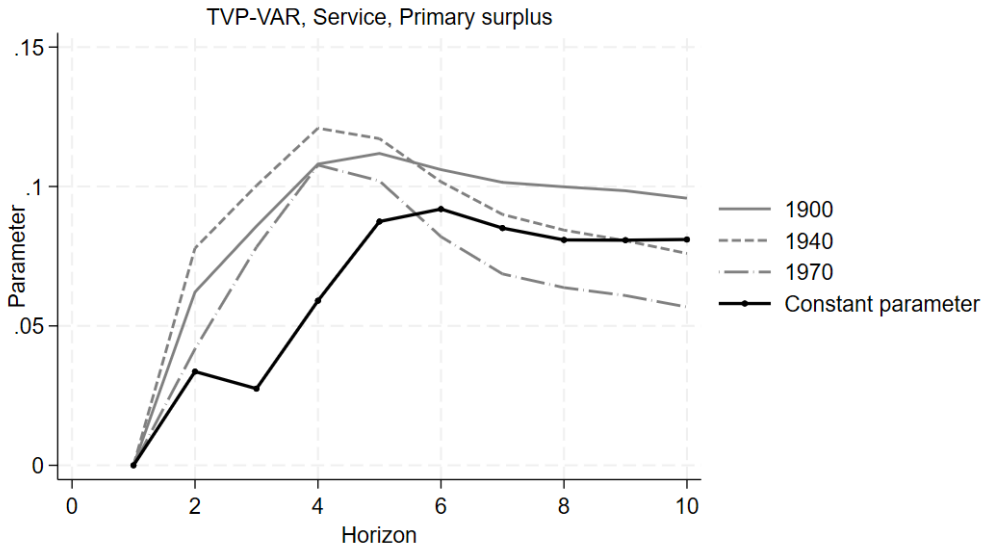


Figure 6 shows that a positive debt-service shock consistently triggers an increase in the primary surplus across all historical periods. The peak effect occurs roughly four years after the shock for the mid-20th century regime and about five years for the earlier period, indicating a slower fiscal response under less institutionalized budget frameworks. The magnitude of the response remains stable across time, around 0.10-0.12% of GDP per standard-deviation shock, confirming the robustness of the service-based adjustment rule. However, the persistence of the effect was stronger before 1900, suggesting slower fiscal correction mechanisms in the premodern U.S. state.

These findings support our central claim: the U.S. government adjusts fiscal policy primarily in response to the *effective cost of debt*—the flow of interest payments—rather than to the *stock of liabilities*. This service-based reaction mechanism has remained a defining feature of American fiscal behavior for over two centuries, adapting its timing and intensity across regimes. While the U.S. case offers a uniquely long historical perspective, it is important to assess whether this service-based fiscal behavior generalizes across advanced economies.

In the next section, we extend the analysis to a multi-country panel.

5. Cross-country Evidence

We now turn to a broader perspective by examining whether our main result generalizes across advanced economies over the long run. A multi-country panel framework enables us to test the *service-based fiscal rule* and to assess how structural heterogeneity-monetary regimes, institutional constraints, and financial development—may shape the strength of fiscal responses.

5.1. Empirical framework

We follow the same approach as in the U.S. case by estimating a debt-service augmented fiscal reaction function. The baseline specification is given by:

$$\log PS_{i,t} = \xi PS_{i,t-1} + \beta \log Debt_{i,t-1} + \gamma \log Service_{i,t} + \upsilon' \mathbf{X}_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t}, \quad (10)$$

where i and t refer to countries and years respectively. $PS_{i,t}$ still denotes the primary surplus-to-GDP ratio, $Debt_{i,t-1}$ the lagged debt-to-GDP ratio, $Service_{i,t}$ the interest payments as a share of GDP. Country fixed effects (μ_i) control for persistent institutional differences, while time fixed effects (δ_t) capture common shocks such as wars, global crises, or monetary realignments.

The panel covers 12 advanced economies—Canada, Denmark, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, the United Kingdom, and the United States—from 1800 to 2023, using annual data from the IMF's *Public Finances in Mod-*

ern History database.[8] Given the long time dimension, we estimate the dynamic panel model using the Least Squares Dummy Variable (LSDV) estimator, which is consistent and efficient when T is large, outperforming GMM or instrumental variables approaches in such contexts (Judson and Owen, 1999; Attanasio et al., 2000).

Table 4: Baseline – The response of the primary surplus to public debt.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Primary surplus							
Primary surplus (t-1)	0.799***	0.797***	0.797***	0.791***	0.804***	0.802***	0.776***	0.790***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.013)	(0.013)	(0.020)	(0.015)
Debt (t-1)	0.145***		0.027	-0.005	0.042	0.032	0.215***	0.193***
	(0.027)		(0.062)	(0.051)	(0.042)	(0.042)	(0.040)	(0.037)
Service		0.155***	0.131**		0.073*			
		(0.026)	(0.062)		(0.039)			
Service (t-1)				0.169***		0.083**		
				(0.053)		(0.039)		
Net service							0.004	-0.001
							(0.005)	(0.004)
Output gap	0.017	0.019	0.018	0.017	0.085***	0.085***	0.040*	0.104***
	(0.017)	(0.017)	(0.017)	(0.017)	(0.016)	(0.016)	(0.022)	(0.020)
Observations	1833	1837	1833	1833	1833	1833	1474	1506
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓			✓	

Notes: Numbers in parentheses are standard errors. All variables are in log. *, ** and *** denote significance at 10%, 5% and 1% levels. In columns (5), (6), and (8), World Wars and the 2008 crisis are controlled for through dummy variables rather than year fixed effects.

The results reported in Table 4 confirm the central finding of the U.S. analysis in a cross-country context. Regressions (3)-(5) unveil that when accounting for the positive and significant impact of the debt service on the primary surplus, the effect of the lagged debt ratio is not significant at usual significance levels.

This finding leads to three main considerations.

First, in standard theoretical frameworks, debt sustainability depends on the sign of the interest–growth differential $(r-g)$. One might therefore wonder whether governments react not to the gross debt service rb, but rather to the growth-adjusted service $(r-g)b$, as suggested by Mauro and Zhou (2021). To test this idea, we replace the debt service term rb with the net service $(r-\gamma)b$ in columns (7)–(8). The coefficient is not significant, indicating that governments adjust fiscal policy in response to realized interest payments—the observable cost of servicing debt—rather than to the interest–growth differential, which is the theoretical benchmark for sustainability. This finding suggests that fiscal behavior is driven by actual financing pressures rather than by the forward-looking arithmetic of debt dynamics.

[8]The output gap is derived as the deviation of actual GDP from potential output, using the Hodrick-Prescott filter. See Table A.8 for variables' definitions and sources.

Second, in the traditional Bohn-type specification without the debt service (column 1), the coefficient on debt is positive, significant, and in line with previous studies (see Checherita-Westphal and Zyárek, 2017, for european countries). This indicates that our finding of an insignificant effect of debt arises not from sample selection, but from the fact that once the debt service is included, it becomes the only significant determinant of the primary surplus. By contrast, in the specification without the debt term (column 2), a 1% increase in the debt service is associated with a significative improvement of about 0.15% in the primary surplus.

Third, the significant response to debt service—and the absence of any significant reaction to debt itself—remains robust across alternative specifications and extensive robustness checks. In Appendix B, we report (i) a set of robustness tables comparing results across alternative estimators, and (ii) a system of simultaneous equations estimated via Three-Stage Least Squares to address potential endogeneity. Both exercises confirm the stability and significance of our main findings.

5.2. Heterogeneous fiscal reactions

We seek to estimate the long run relation between the primary surplus and the debt service, controlling for heterogeneity both between countries and over time. The changes in the primary surplus or the debt service of these countries are also heterogeneous. Therefore, we employ the Mean Group (MG) estimator, which accounts for both cross-country and time heterogeneity:

$$\begin{aligned}\Delta \log PS_{i,t} = \phi_i(\log PS_{i,t-1} - \theta_0 - \theta_{1i} \log Service_{i,t} - \theta_{2i} \log Output\ Gap_{i,t}) \\ - \delta_{1i} \Delta \log Service_{i,t} - \delta_{2i} \Delta \log Output\ Gap_{i,t} + \varepsilon_{i,t}.\end{aligned} \tag{11}$$

Table 5 reports the long-run elasticities of the primary surplus with respect to debt service, estimated using the Mean Group (MG) estimator for the periods 1800-2023 (columns 1-2) and 1916-2023 (columns 3-4).

The results reveal substantial heterogeneity across countries and time periods. Over the long historical horizon (1800-2023), only a few countries—Canada, Italy, Norway, Spain, and the United Kingdom—display significant reactions with long-run elasticities above unity, thus satisfying our sustainability condition. Other economies, such as the Netherlands, Denmark, and Portugal, exhibit significant but insufficient responsiveness, while France, Germany, Sweden, and the United States show no statistically significant reaction to debt-service pressures. In contrast, during the modern era (1916-2023), the United States becomes significantly reactive, whereas Norway, Portugal, Spain, and Italy lose statistical significance. The United Kingdom stands out with a markedly high elasticity (around 4.6), implying a strong corrective fiscal stance.

The contrast between the two periods is informative. Over the full historical horizon, more countries satisfy the sustainability condition ($\phi > 1$), while in the modern period only the United Kingdom, the United States, and Canada do so. This difference likely

reflects temporal heterogeneity in fiscal behavior: when estimated over a longer horizon, fiscal responses capture infrequent but strong consolidation episodes, resulting in higher average elasticities; when focusing on the modern period, fiscal policy appears more stable but less reactive on average, consistent with smoother adjustment dynamics around a sustainable path.

Table 5: Long run elasticity estimates of debt service on primary surplus

	(1)	(2)	(3)	(4)
Dependent variable : Primary surplus				
	1800-2023		1916-2023	
Country	Elasticity	Std. Errors	Elasticity	Std. Errors
Canada	1.1029***	0.2896	1.3436**	0.5462
Denmark	0.5979***	0.1911	0.4846**	0.2399
France	0.1412	0.9356	-0.2718	0.7279
Germany	0.5102	0.3619	0.3802	0.3576
Italy	1.8355*	1.0161	1.2301	0.8625
Netherlands	0.7453**	0.3223	0.7046**	0.3265
Norway	1.3657**	0.5782	0.5028	0.6434
Portugal	0.5986**	0.2938	0.4004	0.258
Spain	1.2195**	0.5694	0.8059	0.6406
Sweden	0.1875	0.1484	0.5951	0.3687
United Kingdom	2.2105***	0.8068	4.6422***	1.3401
United States	0.1964	0.2647	1.5746*	0.9554

Notes: The reported coefficients and standard errors are associated with the debt service. The set of explanatory variables include the dependent variable, debt service and the output gap. All variables are in log and lagged by one year. *, ** and *** denote significance at 10%, 5% and 1% levels.

6. Conclusion

This paper reassesses the behavioral foundations of fiscal sustainability. Using two centuries of data for the United States and a panel of advanced economies, we show that fiscal policy responds primarily to the *flow cost* of debt—the burden of interest payments—rather than to the *stock* of liabilities. Across specifications, debt service consistently explains fiscal adjustment dynamics, while debt levels do not. In the United States, the short-run elasticity of the primary surplus with respect to debt service averages around 0.7, and rises above unity in the long run (1916-2023), consistent with sustainable debt dynamics. Over the full historical period (1800-2023), however, the elasticity hovers around one, suggesting a weaker and slower adjustment mechanism.

These results have three main implications. First, fiscal solvency should be assessed relative to the effective cost of debt, not its level: what constrains governments is the flow of interest payments they face. Second, the sustainability condition is behavioral rather

than mechanical: debt remains stable only when fiscal effort increases more than proportionally with debt-service costs. Third, fiscal discipline is inherently state-dependent—tightening quickly under favorable growth conditions or rising risk premia, but with significant delays during recessions.

Future research should pursue three directions. First, refining the long-run dataset and filling historical gaps would strengthen the empirical foundations of fiscal reaction estimates. Second, integrating narrative identification of debt-service shocks could help distinguish deliberate policy actions from automatic responses to market pressures. Finally, extending the analysis to emerging economies and to the post-pandemic period would test the generality of the flow-based rule under diverse institutional and macrofinancial regimes.

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Appendix A.

Table A.6: Summary statistics - United States (1800-2023)

Variable	Obs	Mean	Std. Dev.	Min	Max
Primary surplus (% GDP)	224	-1.06	4.26	-18.39	6.08
Service (% GDP)	224	1.15	1.02	0	3.86
Debt (% GDP)	224	34.09	32.6	0	131.83
GDP growth	224	3.66	4.88	-13.17	19.73
Inflation	224	1.61	5.62	-15.73	25.14
Trade openness	168	0.04	0.02	0.02	0.10
Risk Premium	96	0.07	0.21	-0.57	0.49
Output gap	224	0	2.80	-9.40	9.77

Table A.7: Summary statistics - United States (1916-2023)

Variable	Obs	Mean	Std. Dev.	Min	Max
Primary surplus (% GDP)	107	-2.63	5.45	-18.39	6.08
Service (% GDP)	107	1.94	0.88	0.05	3.86
Debt (% GDP)	107	60.91	27.73	5.72	131.83
GDP growth	107	3.29	4.77	-13.05	18.38
Inflation	107	3.3	4.82	-10.68	20.49
Trade openness	81	0.05	0.02	0.02	0.10
Risk Premium	96	0.07	0.21	-0.57	0.49
Output gap	107	0	3.07	-9.40	9.77

Table A.8: Variables' definitions and sources

Variable	Sample	Description	Source
Primary Surplus	US & Panel	Government primary balance (in % of GDP)	IMF Public Finances in Modern History
Debt	US &Panel	General government debt (in % of GDP)	IMF Public Finances in Modern History
Debt Service	US &Panel	Interest payment on government debt (in % of GDP)	IMF Public Finances in Modern History
Output Gap	US & Panel	HP filter applied to the real GDP series	Authors' computation GDP series from Maddison Project Database (Bolt and Zanden, 2025)
Trade Openness	US	Sum of exports and imports of goods and services (in % of GDP)	1800-2014: World Trade Historical Database (Federico and Tena Junguito, 2016) 2014-2023: World Bank Indicators
Inflation	US	Consumer Price Index Annual Percent Change	Federal Reserve Bank of St. Louis
Risk Premium	US (1928-2023)	The difference in the annualized return on stocks and the annualized return on T.Bonds	Equity Risk Premiums (ERP) NYU Stern School of Business
Bond Yield	US (1928-2023)	It measures the annual return on 10-year U.S. bonds computed from FRED constant-maturity yields by repricing bonds each year at par and including coupon payments	Equity Risk Premiums (ERP) NYU Stern School of Business
Real long term interest rate	US & Panel	Real long term government bond yield (in %)	IMF Public Finances in Modern History
Real GDP growth	US & Panel	Real GDP growth rate (in %)	IMF Public Finances in Modern History
FED independence	US	Takes the value 1 following the 1951 Treasury-Fed Accord	
NBER recession	US	Takes the value 1 in years classified as recessions by the NBER	NBER Business Cycle Dating

Figure A.8: Debt service and long-term interest rate in United States from 1800 to 2023

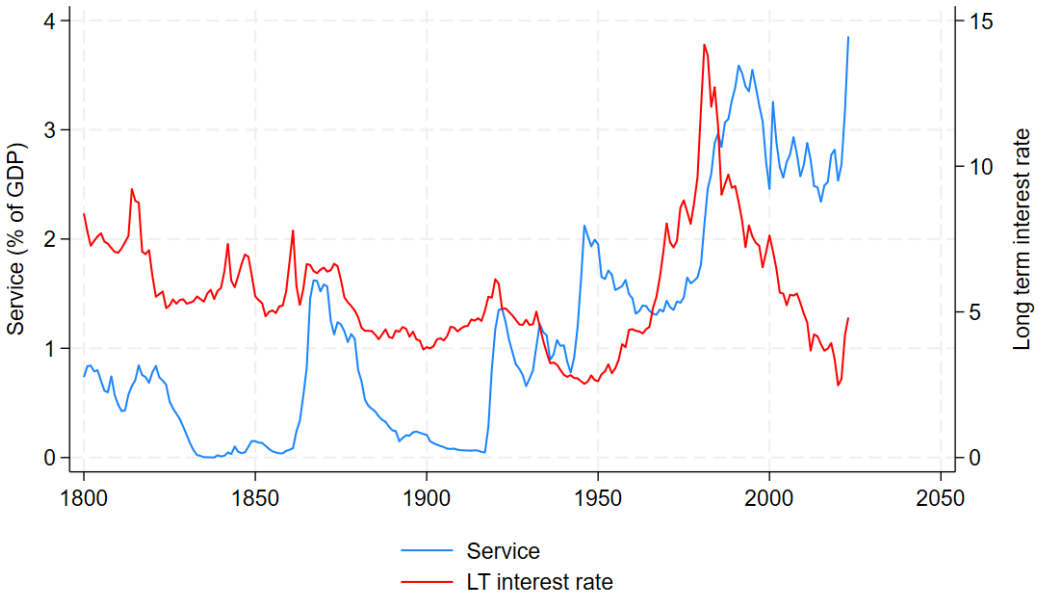


Table A.9: Standard Bohn-type test without debt service

Variables	(1) Primary surplus	(2)	(3)
Primary surplus (t-1)	0.840***	0.844***	0.829***
	(0.0791)	(0.0750)	(0.0776)
Debt (t-1)	0.444**	0.464**	0.475**
	(0.204)	(0.212)	(0.222)
Output gap (t-1)	0.001	-0.009	0.008
	(0.078)	(0.077)	(0.076)
Inflation (t-1)		0.012	0.007
		(0.032)	(0.032)
Trade openness (t-1)	-5.773	-6.637	-3.743
	(5.902)	(6.012)	(5.920)
2008 crisis			-2.038***
			(0.308)
Constant	-1.467*	-1.537*	-1.676**
	(0.758)	(0.785)	(0.811)
Observations	83	83	83

Notes: Numbers in parentheses are robust standard errors. Primary surplus, debt, service and output gap are in log. The estimates cover the period from 1916 to 2008. *, ** and *** denote significance at 10%, 5% and 1% levels.

Table A.10: Extension – The response of the primary surplus to yield debt in the United States

Variables	(1) Primary surplus	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Primary surplus (t-1)	0.817***	0.792***	0.810***	0.785***	0.816***	0.793***	0.791***	0.759***
	(0.081)	(0.078)	(0.084)	(0.081)	(0.089)	(0.084)	(0.085)	(0.082)
Debt (t-1)	0.198	0.230	0.251	0.296	0.297	0.345	-0.063	-0.035
	(0.252)	(0.256)	(0.248)	(0.248)	(0.283)	(0.287)	(0.358)	(0.360)
Service (yield)	-0.022		-0.015		-0.014		-0.025	
	(0.019)		(0.019)		(0.021)		(0.018)	
Service (yield) (t-1)		-0.004		0.002		0.001		-0.003
		(0.019)		(0.019)		(0.020)		(0.019)
Output gap (t-1)	0.015	0.012	0.028	0.030	0.039	0.045	-0.054	-0.057
	(0.046)	(0.045)	(0.045)	(0.044)	(0.064)	(0.062)	(0.072)	(0.075)
FED indep.	0.561*	0.623*	0.571*	0.635*	0.591	0.656*	0.479	0.548
	(0.331)	(0.335)	(0.333)	(0.337)	(0.372)	(0.381)	(0.385)	(0.393)
Inflation (t-1)					-0.023	-0.021	-0.013	-0.011
					(0.029)	(0.029)	(0.027)	(0.027)
Crisis								
2001			-0.309	-0.244	-0.337	-0.278		
			(0.209)	(0.238)	(0.210)	(0.243)		
2008	-1.818***	-2.047***	-1.942***	-2.117***	-1.985***	-2.153***		
	(0.282)	(0.137)	(0.283)	(0.133)	(0.313)	(0.153)		
2020			-1.650***	-1.901***	-1.726***	-1.964***		
			(0.352)	(0.231)	(0.409)	(0.283)		
NBER recessions (t-1)							-0.757***	-0.797***
							(0.259)	(0.250)
Constant	-1.334	-1.595	-1.565	-1.872*	-1.693	-2.017*	0.0815	-0.182
	(0.957)	(0.997)	(0.946)	(0.968)	(1.090)	(1.125)	(1.486)	(1.502)
Observations	96	95	96	95	96	95	96	95
WWII					✓	✓	✓	✓

Notes: Numbers in parentheses are standard errors. Primary surplus, Debt, Service and Output gap are in log. The estimates cover the period from 1928 to 2023. The errors are not auto-correlated according to Portmanteau tests. *, ** and *** denote significance at 10%, 5% and 1% levels.

Table A.11: Unit Root Tests

Variable	**PP(10)**	**ADF(4)**	**KPSS(10)**	**Conclusion**
Primary surplus	-4.491***	-3.639**	0.080	Stationary
Debt service	-2.993	-3.322*	0.114	No rejection
Debt	-3.246*	-3.421*	0.086	Stationary
Inflation	-8.444***	-5.100***	0.041	Stationary
Risk Premium	-10.315***	-5.600***	0.089	Stationary
Critical values				
5%	-3.434	-3.434	0.146	
1%	-3.999	-4.000	0.216	

Notes: *, ** and *** denote significance at 10%, 5% and 1% levels. All results are reported for an AR(4) in ADF and for 10 lags in PP and in KPSS to account for short-run dependencies.

Table A.12: Granger causality test with debt service

Equation	**Excluded**	**Chi2**	**df**	**P >Chi2**
Primary surplus	Debt service	9.5646	4	0.048
	Output gap	7.2368	4	0.124
	All	16.013	8	0.042
Debt service	Primary surplus	15.466	4	0.004
	Output gap	5.0771	4	0.279
	All	21.178	8	0.007
Output gap	Primary surplus	5.7154	4	0.221
	Debt service	4.1135	4	0.391
	All	11.417	8	0.179

Notes: Debt service causes primary surplus. Primary surplus causes debt service

Table A.13: Granger causality test with debt

Equation	**Excluded**	**Chi2**	**df**	**P >Chi2**
Primary surplus	Debt	5.6046	4	0.231
	Output gap	6.4975	4	0.165
	All	11.942	8	0.154
Debt	Primary surplus	6.2648	4	0.18
	Output gap	0.42171	4	0.981
	All	6.607	8	0.58
Output gap	Primary surplus	7.508	4	0.111
	Debt	1.0599	4	0.901
	All	8.2635	8	0.408

Notes: There is no evidence of causal relationship between variables.

Appendix B. Robustness of the Panel Estimates

Appendix B.1. Alternative estimation methods

The significant response of the primary surplus to the debt service combined with a non-significant response of debt are robust to different estimation methods. Table B.14 presents estimations based on country fixed effects method without and with an AR(1) error structure (columns 1-2 and 3-4, respectively); and correcting for both serial correlation and the possibility of cross-sectional dependence in the error term (columns 5-6). For each method we consider both the current debt service and its lagged value as an alternative measure.

Table B.14: Robustness—Panel-corrected estimates of primary surplus

	(1)	(2)	(3)	(4)	(5)	(6)
	FE		AR(1)		PC	
Variables	Primary surplus					
Primary surplus (t-1)	0.799***	0.793***	0.805***	0.799***	0.794***	0.787***
	(0.014)	(0.015)	(0.014)	(0.014)	(0.015)	(0.015)
Debt (t-1)	0.032	0.002	0.031	0.002	0.021	-0.010
	(0.056)	(0.055)	(0.056)	(0.054)	(0.055)	(0.054)
Service	0.123**		0.121**		0.141***	
	(0.0550)		(0.054)		(0.053)	
Service (t-1)		0.159***		0.156***		0.177***
		(0.053)		(0.053)		(0.051)
Output gap (t-1)	-0.007	-0.006	-0.007	-0.006	-0.008	-0.007
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Constant	-0.208	-0.099	-0.215	-0.110	-0.174	-0.0590
	(0.533)	(0.533)	(0.533)	(0.533)	(0.535)	(0.534)
Observations	1843	1843	1843	1843	1843	1843
Number of country	12	12	12	12	12	12
Country FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
AR rho			-0.0190	-0.0175	-0.0403	-0.0434

Notes: Numbers in parentheses are standard errors. Primary surplus, Debt, Service and Output gap are in log. The estimates cover the period from 1800 to 2023. FE estimation corrects for heteroskedasticity and cross-sectional dependence. AR(1) refers to fixed-effects estimations with an AR(1) error structure. PC is Panel-corrected estimation with an AR(1) structure that corrects for both autocorrelation and cross-sectional dependence in the error term. *, ** and *** denote significance at 10%, 5% and 1% levels.

Appendix B.2. Simultaneous-equation evidence

To address potential bidirectional causality between debt, debt service, and primary surplus, we estimate a dynamic system of simultaneous equations using Three-Stage Least

Squares (3SLS):

$$\log PS_{i,t} = \beta_0 + \beta_1 \log PS_{i,t-1} + \beta_2 \log Debt_{i,t} + \beta_3 \log Service_{i,t} + \beta_4 Output\ gap_{i,t} + \epsilon_{i,t}, \tag{B.1}$$

$$\log Debt_{i,t} = \lambda_0 + \lambda_1 \log Debt_{i,t-1} + \lambda_2 \log PS_{i,t} + \lambda_3 \log Service_{i,t} + \lambda_4 Exp_{i,t} + \lambda_5 r_{i,t} + \epsilon_{i,t}, \tag{B.2}$$

$$\log Service_{i,t} = \theta_0 + \theta_1 \log Service_{i,t-1} + \theta_2 \log PS_{i,t} + \theta_3 \log Debt_{i,t} + \theta_4 r_{i,t} + \epsilon_{i,t}, \tag{B.3}$$

where i and t refer to countries and years respectively, $PS_{i,t}$ is the primary surplus (in % of GDP), $Debt_{i,t}$ is the public debt (in % of GDP), $Service_{i,t}$ is the debt service (interest payments on public debt, in % of GDP), $Output\ gap_{i,t}$ is the output gap (in % of potential GDP), $\epsilon_{i,t}$ is the error term.

In Eqs. (B.1)-(B.3), we allow our dynamic simultaneous-dynamic models to have a dynamic panel specification where the lagged dependent variables can affect their current levels. Eqs. (B.2)-(B.3) postulate that debt and debt service are also influenced by the primary expenditure—in % of GDP ($Exp_{i,t}$)—and the long-term real interest rate ($r_{i,t}$). Our dynamic models in panel data are simultaneously estimated by using the Three-Stage Least Squares (3SLS) in order to address potential endogeneity.

The results of Table B.15 corroborate our findings. The primary surplus reacts positively and significantly to the debt service, with an elasticity of about 0.09, while the response to the debt ratio remains insignificant (column 1). This result holds even after controlling for lagged public debt (column 2). In addition, the negative feedback of the primary surplus on both debt and debt service confirms that fiscal adjustments contribute to stabilizing debt trajectories through the channel of interest payments.

Table B.15: 3SLS—The response of the primary surplus

	Dependent variables					
	Primary surplus		Debt		Debt service	
Independent variables	(1)	(2)	(1)	(2)	(1)	(2)
Primary surplus			-0.025***	-0.020***	-0.033***	-0.026***
			(0.002)	(0.002)	(0.003)	(0.003)
Primary surplus (t-1)	0.824***	0.823***				
	(0.014)	(0.014)				
Debt	0.053				0.009	0.007
	(0.055)				(0.010)	(0.010)
Debt (t-1)		0.056	0.964***	0.963***		
		(0.052)	(0.007)	(0.007)		
Service	0.090*	0.087*	0.029***	0.026***		
	(0.047)	(0.046)	(0.007)	(0.007)		
Service (t-1)					0.978***	0.975***
					(0.009)	(0.008)
Output gap	0.092***	0.074***				
	(0.018)	(0.018)				
Primary expenditure			0.001**	0.001**		
			(0.000)	(0.000)		
LT real interest rate			0.003***	0.003***	0.004***	0.004***
			(0.001)	(0.001)	(0.001)	(0.001)
Observations	1512	1512	1512	1512	1512	1512

Notes: Numbers in parentheses are standard errors. Primary surplus, debt, service are in log. *, ** and *** denote significance at 10%, 5% and 1% levels.