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REM Working Paper 0426-2026

August 2026

REM – Research in Economics and Mathematics

Rua Miguel Lúpi 20,
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Portugal

ISSN 2184-108X

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Informality and Fiscal Adjustment under Stress: Evidence from Developing Economies^{*}

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August 2026

Abstract

How does informality shape fiscal adjustment when governments face debt stress? We study 122 non-advanced economies from 1990 to 2020 by embedding shadow-economy exposure in fiscal reaction functions, debt-dynamics decompositions, and state-dependent impulse responses. The central design uses predetermined pre-2008 informality and the common timing of the Global Financial Crisis. Countries with higher pre-crisis informality run a larger post-2008 primary balance, a differential of roughly 0.6 to 1.5 percentage points of GDP, against a sample-mean deficit near 0.8 percent after absorbing country effects, common shocks, and region-year shocks; event-study estimates cannot reject parallel pre-trends before the shock (a test with limited power), and the post-2008 break survives netting out a linear pre-trend. The result survives country trends, outcome winsorization, alternative event windows, country-level randomization inference, and full leave-one-country-out diagnostics. Mechanism tests show that the primary balance is the main adjustment margin, with weaker evidence of revenue effort and little support for a clean expenditure, growth, snowball, or debt-stock channel. A fiscal-rule adoption event study provides a non-GFC scope check: pre-trends are clean, but the informality differential is short-lived rather than persistent. We do not find a stable universal pooled interaction coefficient; fixed-effects, IV, and GMM estimates of the average debt-response gradient are often imprecise. The evidence supports a narrower claim: informality becomes fiscally consequential when stress tightens governments' room for manoeuvre, forcing sharper primary-balance adjustment rather than indicating stronger underlying fiscal capacity.

Keywords: Shadow economy, fiscal sustainability, fiscal reaction function, time-varying parameters, debt dynamics, fiscal space, developing countries

JEL: E26, E62, H63, O17, C23

^{*} This work was supported by national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., in the framework of the unit UID/06522/2025 – <https://doi.org/10.54499/UID/06522/2025>. The opinions expressed herein are those of the authors and do not necessarily reflect those of the authors' employers. Any remaining errors are the authors' sole responsibility.

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1. Introduction

Developing-country fiscal sustainability is usually evaluated through debt ratios, interest-growth differentials, fiscal rules, and institutional quality. In economies with large informal sectors, however, the binding question is also one of adjustment capacity. When debt rises and financing conditions deteriorate, can the state generate primary surpluses from a narrow formal tax base without destabilizing the economy? Informality makes that problem harder because it limits the enforceable tax base, weakens compliance, reduces the reach of automatic stabilizers, and leaves governments with a thinner set of adjustment instruments when shocks arrive.

The standard fiscal-sustainability framework of Bohn (1998) formalizes this problem through the fiscal reaction function: sustainable policy requires the primary balance to respond positively to lagged debt. The framework has been used extensively to study advanced economies, nonlinear debt responses, fiscal fatigue, and time-varying fiscal behaviour (Bohn, 2008; Ghosh et al., 2013; Checherita-Westphal and Zdárek, 2017). It has been used far less to study a central structural feature of developing economies: informality. That omission matters because a government facing a large shadow economy does not simply choose a fiscal response from a given policy menu. The menu itself is constrained by how much economic activity lies outside the tax and regulatory net.

This paper asks how informality shapes fiscal adjustment under stress. The wording is deliberately narrow. We do not argue that informality has one invariant effect on the average fiscal reaction coefficient in every country and year. We instead test whether informality changes the way governments adjust when fiscal conditions become difficult. The empirical setting is a panel of 122 non-advanced economies observed from 1990 to 2020, combining shadow-economy measures, fiscal outcomes, institutional controls, and alternative labour-market informality data. We embed informality in fiscal reaction functions, allow the informality-debt relationship to vary over time, and study debt-dynamics channels, thresholds, and local projections.

The conceptual distinction running through the paper is between fiscal capacity and observed fiscal adjustment. A large informal sector lowers the formal tax base and raises the cost of durable revenue mobilization. Yet once stress tightens financing constraints, that weakness can also force sharper primary-balance correction through spending compression, temporary revenue measures, or accelerated consolidation. A larger post-shock primary-balance response among high-informality countries therefore need not signal stronger fiscal institutions. It may instead reveal less room to smooth the shock.

The paper’s cleanest identification comes from the common timing of the 2008-2009 Global Financial Crisis. We measure each country’s shadow economy before the crisis and ask whether economies with higher predetermined informality followed different post-2008 primary-balance paths after absorbing country effects, common shocks, and region-year shocks. This design does not require informality itself to be randomly assigned. It requires the timing of the global shock to be external to individual developing economies and compares countries that entered that shock with different informal-sector exposure. The estimates show that higher pre-crisis informality predicts a distinct post-2008 primary-balance path. The result holds with binary and continuous exposure measures, and an event-study specification cannot reject parallel pre-trends before 2008, despite the limited power of this test. Moreover, the post-2008 break survives the inclusion of a differential linear pre-trend.

The remaining evidence is organized as support and discipline for that design. High-standard robustness checks show that the GFC coefficient survives country trends, region-year shocks, outcome winsorization, alternative event windows, country-level randomization inference, and full leave-one-country-out diagnostics. A fiscal-rule adoption event study provides a non-GFC timing check: pre-trends are clean, but the informality differential is short-lived rather than persistent, so the exercise supports the scope of the claim without replacing the crisis design. Time-varying and rolling-window estimates show the informality-debt relationship deteriorating around the same post-2008 period. Debt-dynamics decompositions and GFC channel regressions identify the primary balance as the main adjustment margin. Threshold and local-projection exercises show that fiscal responses differ across informality regimes. By contrast, pooled fixed-effects, IV, and system-GMM estimates of the average informality-debt interaction are sensitive to specification and often imprecisely estimated. That mixed pooled evidence is informative: it suggests that the fiscal role of informality is episodic and state-dependent, not well summarized by one average slope.

The interpretation is accordingly cautious. A positive post-2008 primary-balance differential in high-informality countries should not be read as evidence that informality improves fiscal capacity. It more plausibly reflects tighter room for manoeuvre: when financing conditions worsen, governments with larger informal sectors must adjust more sharply because they cannot rely on broad, resilient tax bases. In this sense, informality is a structural constraint on fiscal capacity even when the pooled interaction coefficient is not stable across all specifications.

The contribution is threefold. First, the paper brings informality into the fiscal reaction function framework for a large developing-country panel, connecting the literature on shadow economies to the literature on debt sustainability. Second, it shifts the empirical focus from average pooled effects to shock-conditioned fiscal adjustment, using pre-crisis informality and the externally timed GFC as the central identification device while adding fiscal-rule adoption as a non-GFC policy-event check. Third, it documents both the mechanisms and the limits of the result: the primary balance is the clearest adjustment channel in both the accounting decomposition and the GFC channel regressions, while nonlinear fiscal-space calculations are useful as policy illustrations but too model-sensitive to be the headline quantitative finding.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 develops the conceptual framework linking informality to fiscal adjustment and debt dynamics. Section 4 describes the data and stylized facts. Section 5 lays out the empirical architecture and evidence hierarchy. Section 6 reports the main results, beginning with the crisis-exposure design. Section 7 discusses robustness and extensions. Section 8 states the limits of the evidence. Section 9 concludes.

2. Literature Review

This paper stands at the intersection of three literatures that have developed largely in parallel: the empirical analysis of fiscal sustainability through fiscal reaction functions, the macroeconomic consequences of informality in developing economies, and the application of time-varying parameter methods to public finance questions. By bringing them together, we address a gap that none has filled on its own: the question of whether, and how, the shadow economy shapes the dynamic evolution of governments' fiscal responses to debt accumulation.

The modern empirical framework for assessing fiscal sustainability originates with Bohn (1998), who demonstrated that a positive response of the primary balance to the lagged debt-to-GDP ratio constitutes a sufficient condition for the government's intertemporal budget constraint to hold, regardless of the current level of debt. This insight shifted the sustainability literature away from unit-root tests on debt series, whose notoriously low power limits their reliability, toward the estimation of fiscal reaction functions, which has since become the dominant empirical approach. Bohn (2008) extended the framework to allow for nonlinear responses and applied it to long historical data for the United States, finding that fiscal policy has consistently satisfied the sustainability

condition over more than two centuries. Ghosh et al. (2013) generalized the approach further by estimating a cubic fiscal reaction function for advanced economies and introducing the concept of fiscal fatigue: the tendency for the primary surplus response to weaken as debt rises to very high levels. Their framework yields natural estimates of debt limits and fiscal space, the gap between a country's current debt and its estimated maximum sustainable level, which have become standard tools in policy analysis (Ostry et al., 2010).

The application of these frameworks beyond the advanced economy context has been more limited but has produced important insights. Mendoza and Ostry (2008) provided the first systematic cross-country evidence on the fiscal reaction function for both advanced and developing economies, establishing that the sustainability condition holds on average for both groups but with considerably more heterogeneity among emerging markets. Celasun et al. (2006) examined primary surplus behaviour in emerging market countries using a fan-chart approach that accounts for fiscal policy uncertainty, documenting a weaker (and statistically fragile) primary-surplus response to debt at high debt levels. More recently, Afonso et al. (2025) studied the determinants of the degree of fiscal sustainability across a panel of 22 OECD economies, and Frankel et al. (2013) documented the graduation of some developing economies from procyclical to countercyclical fiscal policy, suggesting that institutional capacity, which is closely linked to formality, shapes the character of fiscal behaviour itself. Yet despite the growing recognition that the fiscal reaction function is not a fixed structural parameter but an object that evolves over time and across institutional environments, no prior study has systematically examined how informality conditions this reaction or how the interaction between informality and fiscal behaviour has changed over time.

The literature on informality and its macroeconomic consequences has grown substantially over the past two decades, driven by improvements in measurement and by the sheer scale of the phenomenon. Shadow economies in developing countries typically account for 25 to 45 percent of official GDP (Medina and Schneider, 2018, 2019), while informal employment represents the dominant form of labour market participation across much of Africa, South Asia, and Latin America (International Labour Organization, 2018; Ohnsorge and Yu, 2022). Schneider and Enste (2000) provided an influential early survey of the causes and consequences of shadow economies, establishing the intellectual foundations for much of the subsequent empirical work. More recent contributions have sharpened both the theoretical understanding and the measurement of informality. La Porta and

Shleifer (2014) offered a dual perspective, characterizing informality not merely as tax evasion but as a distinct organizational mode associated with small firms, low productivity, and weak contract enforcement. Loayza (2016) situated informality within a broader development process, showing that it tends to decline with income but can persist even at relatively high levels of development when institutions remain weak. Ulyssea (2020) provided a comprehensive review of the causes and consequences of informality, emphasizing the heterogeneity of the informal sector and the inadequacy of one-size-fits-all policy responses. Perry et al. (2007) distinguished between voluntary exit from formality, driven by regulatory costs and weak enforcement, and involuntary exclusion from formal employment, driven by segmented labour markets, a distinction with direct implications for the fiscal effects of informality.

The fiscal implications of informality are among the most consequential and yet least systematically studied of its macroeconomic effects. The theoretical logic is compelling: the informal sector reduces the effective tax base, raises the administrative cost of revenue collection, and creates incentive structures in which tax evasion in the formal sector is reinforced by the visibility of untaxed informal competitors. Besley and Persson (2014) formalized these mechanisms in a model of fiscal capacity, showing that economies with large informal sectors are trapped in a low-tax, low-public-goods equilibrium from which escape requires costly investments in state capacity. Gaspar et al. (2016) estimated that there exists a tipping point in tax-to-GDP ratios below which growth prospects are severely constrained, and informality is a primary determinant of whether countries fall below this threshold. Complementing this structural perspective, Dellas et al. (2024) show in a DSGE model calibrated to Greece's consolidation episode that tax-based adjustment in the presence of a large and elastic informal sector can erode revenues by reallocating activity away from the tax base, weakening both output and revenue outcomes. Loayza and Rigolini (2011) document a dual role for informality: it acts as a safety net during downturns while constraining long-run growth, yielding net fiscal effects that depend on the institutional environment. Bachas et al. (2024) examine the interaction between informality, consumption taxes, and redistribution, showing that the optimal tax structure depends critically on the size of the informal sector. More broadly, Ilzetzki et al. (2013) showed that fiscal multipliers are systematically lower in developing economies, a finding consistent with fiscal leakage through the informal sector.

What is conspicuously absent from both literatures, however, is a systematic analysis of how the fiscal consequences of informality aggregate to affect fiscal sustainability in

the Bohn (1998) sense, that is, the government's capacity to adjust fiscal policy in response to rising debt. The fiscal sustainability literature has remained largely agnostic about the structural features of developing economies that might shape the fiscal reaction function, while the informality literature has focused on revenue levels and tax design without examining the dynamic relationship between informality and debt-stabilizing fiscal behaviour. The few studies that have touched on related questions have done so indirectly. Mendoza and Oviedo (2006) modelled fiscal policy under uncertainty in developing countries, emphasizing the role of sudden stops and limited access to credit markets, but did not incorporate informality as a determinant of fiscal capacity. Eichengreen and Panizza (2016) questioned the ability of European economies to sustain large primary surpluses over extended periods, and their fiscal fatigue argument applies *a fortiori* to developing economies where informality constrains the revenue side of the fiscal equation. Auerbach and Gorodnichenko (2017) explored the tension between fiscal stimulus and fiscal sustainability, but again without considering the structural constraints imposed by large informal sectors.

Our paper fills this gap by embedding informality directly in the fiscal reaction function framework and by asking when its fiscal consequences become visible. The theoretical contribution is to distinguish the state's underlying fiscal capacity from the observed primary-balance adjustment that occurs once financing constraints bind. A large informal sector lowers the tax base and raises the cost of durable adjustment, but precisely for that reason it can also force sharper primary-balance correction when market access tightens. The time-varying dimension is essential for at least two reasons. First, both informality levels and the institutional capacity of governments change over the course of economic development, so the fiscal impact of informality at any given point in time reflects a configuration of structural features that may be quite different from that of a decade earlier. Second, the severity of the fiscal constraints imposed by informality is likely to be state-dependent: in tranquil periods, governments may be able to manage moderate informality without visible consequences for debt dynamics, while in periods of global financial stress the same level of informality may sharply restrict room for manoeuvre. For this reason, the paper places particular emphasis on the common timing of the Global Financial Crisis and on predetermined differences in pre-crisis informality.

On the methodological front, time-varying parameter models have become standard in macroeconometrics since the work of Primiceri (2005) on TVP-VARs with stochastic

volatility, and Canova and Ciccarelli (2009) extended these methods to multi-country settings. In the fiscal sustainability literature specifically, time variation has typically been examined through structural break tests or crude sample splitting, both of which impose discrete regime changes rather than allowing for the gradual evolution that economic logic suggests. Rolling-window estimation provides a nonparametric alternative but is sensitive to the choice of window width and suffers from boundary effects. Local projections (Jordà, 2005) offer a complementary perspective by tracing dynamic responses to identified shocks, and threshold models (Hansen, 1999) can reveal critical levels at which the relationship between informality and fiscal behaviour changes qualitatively. Our approach combines these methods, namely Kalman-smoothed TVP estimates, rolling-window panel regressions, parametric time-trend interactions, local projections, and threshold models to provide a robust and multi-dimensional picture of time variation in the informality-fiscal sustainability nexus.

The contribution of this paper is therefore threefold. First, we introduce informality as a state variable in fiscal reaction functions for developing economies, bridging the fiscal sustainability and informality literatures. Second, we provide shock-conditioned evidence that countries entering the Global Financial Crisis with larger shadow economies followed distinct post-2008 primary-balance paths, while pre-crisis event-study coefficients cannot reject parallel trends (and the break is robust to honest difference-in-differences sensitivity bounds). Third, we show why that result should be interpreted as constrained adjustment rather than stronger fiscal capacity: the supporting evidence points to the primary balance as the main margin, to regime dependence in local projections and thresholds, and to model-sensitive fiscal-space calculations that are useful as policy illustrations but not as precise debt-limit estimates.

3. Conceptual framework

The theoretical logic of this paper rests on a straightforward but consequential observation: the standard debt accumulation identity constrains the set of fiscal policy paths consistent with long-run solvency, and the tightness of that constraint depends jointly on macroeconomic conditions and on the structural features of the economy chief among them, the size of the informal sector. To understand why informality matters for sustainability, rather than merely for the level of the deficit, it is necessary to formalize the link between shadow economic activity, government behaviour, and debt dynamics.

Consider the canonical law of motion for the debt-to-GDP ratio:

$$d_t = \frac{1+r_t}{1+g_t} d_{t-1} - pb_t + sfa_t, \quad (1)$$

where d_t denotes government debt as a share of GDP, r_t is the effective nominal interest rate on outstanding debt, g_t is the nominal GDP growth rate, pb_t is the primary balance as a share of GDP, and sfa_t captures stock-flow adjustments arising from exchange rate valuation effects, below-the-line operations, and other discrepancies between deficit flows and debt stocks. When $r_t > g_t$, the debt ratio rises automatically unless the primary balance is sufficiently large to offset this snowball effect; when $r_t < g_t$, the government enjoys a degree of fiscal space that permits smaller surpluses or even deficits without debt explosion. The change in debt can be decomposed as:

$$\Delta d_t \approx \underbrace{\left(\frac{r_t - g_t}{1 + g_t} \right) d_{t-1}}_{\text{snowball effect}} - \underbrace{pb_t}_{\text{primary balance}} + \underbrace{sfa_t}_{\text{stock-flow adj.}} \quad (2)$$

This decomposition provides the organizing structure for our empirical analysis of the channels through which informality affects debt dynamics: it can operate through the primary balance (by constraining revenue or inflating expenditure), through the snowball effect (by depressing growth or raising borrowing costs), or through both simultaneously.

The key insight of Bohn (1998) was to reformulate the sustainability question as a behavioural one. Rather than asking whether the debt ratio is stationary, a question that unit-root tests answer with notoriously low power in fiscal data, one can ask whether fiscal policy responds to debt in a stabilizing manner. If the primary balance reacts positively to the lagged debt ratio, then the intertemporal budget constraint is satisfied regardless of the current level of debt. This motivates the fiscal reaction function, which in our setting takes the form:

$$pb_{it} = \rho_t d_{it-1} + \beta_t s_{it} + \delta_t (s_{it} \times d_{it-1}) + \gamma_t' X_{it} + \alpha_i + \varepsilon_{it} \quad (3)$$

where s_{it} is the size of the shadow economy in country i at time t , X_{it} is a vector of cyclical and structural controls including the output gap, expenditure gap, and trade openness, and α_i captures time-invariant country heterogeneity. The subscript t on the coeffi-

cients is deliberate: there is no theoretical reason to expect the fiscal reaction to be constant over time or across states of the world, and allowing for time variation is central to the contribution of this paper.

Three parameters govern the relationship between informality and fiscal sustainability. The coefficient ρ_t captures the baseline fiscal response to debt, the parameter that must be positive for the Bohn (1998) sustainability condition to hold. The coefficient β_t measures the direct effect of informality on the primary balance, net of its interaction with debt. The coefficient δ_t is the key parameter of interest: it captures how informality modifies the fiscal response to debt accumulation. The marginal fiscal response to debt is therefore state-dependent:

$$\frac{\partial pb_{it}}{\partial d_{it-1}} = \rho_t + \delta_t s_{it}. \quad (4)$$

If $\delta_t < 0$, informality weakens fiscal sustainability by reducing the government's ability to generate primary surpluses in response to rising debt. The sustainability condition becomes harder to satisfy for countries with larger shadow economies: it requires $\rho_t + \delta_t s_{it} > 0$, which for a sufficiently large s_{it} may fail even when ρ_t is positive. In other words, fiscal behaviour that would be sustainable in a fully formal economy may become unsustainable once a large informal sector is considered.

This reduced-form expression is useful, but it leaves an important ambiguity unresolved. A high-informality country may have weaker fiscal capacity and still display a larger observed improvement in the primary-balance after a shock. The reason is that fiscal capacity and fiscal adjustment are distinct concepts. Capacity refers to the state's ability to raise durable revenue or reallocate expenditure, whereas adjustment is the observed policy response, which may be forced by market access, external conditionality, or rollover pressure.

To make this distinction explicit, suppose that the formal tax base is $B(s_{it}) = 1 - \emptyset s_{it}$, with $\emptyset > 0$, so that informality lowers the share of output that can be taxed at normal administrative cost. Let ω_t denote a stress state, equal to zero in tranquil periods and positive when global financing conditions tighten. The primary-balance improvement required to stabilize debt can be written schematically as:

$$a_{it}^{req} = [\bar{\zeta}_t + \omega_t(\chi_0 + \chi_1 s_{it})]d_{it-1} + \omega_t \chi_2 s_{it}, \quad \chi_0, \chi_1, \chi_2 \geq 0, \quad (5)$$

where ζ_t summarizes the common interest-growth environment and the χ terms capture the idea that stress raises required adjustment more sharply where informality is high. This may occur because investors attach a larger risk premium to a narrow tax base, because external financing becomes harder to roll over, or because adjustment programs demand faster primary-balance correction when revenue capacity is weak.

The government can produce a primary-balance improvement through tax and compliance effort e_{it} and through spending compression or temporary measures c_{it} :

$$a_{it} = B(s_{it})e_{it} + c_{it}. \quad (6)$$

The cost of doing so is increasing in informality because the same tax effort yields less revenue when the formal base is narrow. A simple cost function is:

$$\mathcal{C}(e_{it}, c_{it}; s_{it}) = \frac{e_{it}^2}{2B(s_{it})} + \frac{\kappa c_{it}^2}{2}, \quad \kappa > 0 \quad (7)$$

Equations (5)-(7) generate the paper's central comparative statics. In tranquil periods, ω_t is small, so informality may weaken revenue capacity without producing a discrete primary-balance break. Under stress, however, $\partial a_{it}^{req} / \partial s_i = \omega_t(\chi_1 d_{1t-1} + \chi_2) > 0$: high-informality governments face larger required adjustment. At the same time, $B'(s) < 0$ makes durable tax-based adjustment more costly, so the adjustment may arrive through a mixture of tax effort, spending compression, arrears clearance, or other primary-balance movements rather than through a clean revenue increase. This is why a positive post-shock coefficient on the primary balance should be interpreted as constrained adjustment, not as evidence that informality improves fiscal capacity.

The conceptual framework that connects informality to this fiscal reaction operates through four distinct but reinforcing channels, each corresponding to a component of the debt decomposition in Equation (2).

The first and most direct is the *revenue channel*. The shadow economy erodes the tax base by definition: if a fraction s of economic activity is informal, the effective tax base shrinks, and revenue falls below what the statutory tax structure would otherwise generate. Formally, government revenue can be expressed as $Rev_t = \tau \cdot (1 - \emptyset \cdot s_{it}) \cdot Y_t$, where τ is the average effective tax rate and $\emptyset \in (0,1)$ captures the degree to which informal

activity escapes taxation. This is the primary channel emphasized by Besley and Persson (2014) in their model of fiscal capacity, where economies with large informal sectors are trapped in a low-tax equilibrium. Gaspar et al. (2016) estimated that countries below a tax-to-GDP tipping point face significantly worse growth prospects, and informality is a first-order determinant of whether this threshold is breached.

The second is the *expenditure channel*. Informality may increase public expenditure through several mechanisms that are difficult to observe individually but plausible in aggregate. Governments with large informal sectors face higher social protection costs to extend coverage beyond formal employment, greater infrastructure spending requirements to offset private-sector underinvestment, and higher governance costs related to monitoring and enforcing tax compliance. The net expenditure effect is empirically ambiguous: some governments may respond by underinvesting in public goods rather than financing them from a constrained revenue base. To the extent that expenditure pressures do rise, however, they reinforce the fiscal squeeze generated by the revenue channel.

The third is the growth channel. The relationship between informality and economic growth is theoretically ambiguous (Loayza and Rigolini, 2011; Loayza, 2016). On the one hand, informality reduces aggregate productivity through the misallocation of resources. Informal firms are typically smaller, less productive, and less innovative than their formal counterparts (La Porta and Shleifer, 2014). On the other hand, the informal sector provides labour market flexibility and serves as a buffer during economic downturns, which may smooth the growth path even if it lowers its trend. The net effect on the interest rate–growth differential ($r - g$) that governs the snowball effect in Equation (2) depends on the relative magnitudes of these opposing forces and is ultimately an empirical question that our debt dynamics decomposition is designed to answer.

A fourth channel operates through sovereign risk premia. Higher informality may raise borrowing costs as international investors perceive weaker fiscal fundamentals and greater uncertainty regarding the government’s ability to service its debt. This channel generates a feedback loop in which informality weakens fiscal capacity, raises risk premia, increases the effective interest rate on government debt, and worsens the snowball effect, further straining fiscal sustainability. The possibility of such amplification mechanisms is what makes the interaction between informality and debt dynamics particularly consequential. A country able to sustain a moderate debt level under low informality may find the same level explosive when informality is high, as lower revenue, weaker fiscal responses, and higher borrowing costs jointly push debt dynamics onto an unstable path.

This nonlinearity is precisely what the interaction term δ_t in Equation (3) is designed to capture.

The debt dynamics framework also provides the foundations for estimating informality-conditional fiscal space, following the approach of Ghosh et al. (2013). If the fiscal reaction function is allowed to be nonlinear in debt, specifically, a cubic polynomial whose coefficients depend on the level of informality, as

$$pb_{it} = f(d_{it-1}, s_{it}) + \gamma' X_{it} + \alpha_i + \varepsilon_{it}, \quad (8)$$

then the debt limit d^* for a given informality level s can be computed as the debt ratio at which the primary balance predicted by the fiscal reaction function can no longer keep pace with the debt-stabilizing requirement:

$$f(d^*, s) = \left(\frac{\bar{r} - \bar{g}}{1 + \bar{g}} \right) d^*. \quad (9)$$

Fiscal space is then the distance between the current debt level and this limit: $d^* - d_{it}$. In theory, higher informality can shift the fiscal reaction function downward through the revenue channel or flatten its slope at high debt levels through the interaction effect, thereby compressing fiscal space. Empirically, however, the resulting debt-limit schedule is a model-sensitive object: finite intersections may exist only over part of the informality grid, and the gradient need not be monotone in a small, unbalanced panel. The policy relevance of the exercise is therefore illustrative rather than calibrational. It shows why standard debt sustainability analyses that ignore informality may misread fiscal capacity in developing economies with large informal sectors, but it should not be interpreted as producing a precise universal debt-limit schedule.

The time-varying dimension of our framework deserves emphasis. The coefficients in Equation (3) carry a time subscript because the channels described above are not static. The revenue impact of informality depends on the structure of the tax system, which evolves as countries reform their fiscal institutions. The growth channel depends on the stage of structural transformation and on global economic conditions. The sovereign risk channel is sensitive to international capital market conditions and investors' assessments of institutional quality, while fiscal policy responses are shaped by political economy constraints such as electoral cycles, coalition stability, and external conditionality that

vary over time. Allowing the interaction coefficient δ_t to evolve is therefore not merely a methodological refinement; it is essential to capturing the economic reality that the fiscal costs of informality are themselves a moving target, potentially intensifying during periods of global financial stress when the constraints imposed by a narrow tax base become most binding.

The framework yields five empirical predictions that discipline the rest of the paper. They are summarized in Table 1. First, informality should matter most when the stress state turns on, which motivates the GFC exposure design. Second, the timing interpretation requires no systematic differential pre-trend before the shock. Third, a positive primary-balance response in high-informality countries should be read as forced adjustment rather than fiscal strength. Fourth, the primary-balance contribution should be the cleanest channel in the debt-dynamics decomposition, while revenue and expenditure components may be less precisely isolated. Fifth, the average pooled interaction may be weak even if informality matters in high-stress or high-informality states, which motivates the time-varying, threshold, and state-dependent local-projection exercises.

Table 1. Theoretical Predictions and Empirical Tests

<i>Prediction</i>	<i>Empirical counterpart</i>	<i>Interpretation</i>
Stress activation	Pre-crisis informality $\times$ post-shock exposure	Informality should matter most when financing conditions tighten, not necessarily as a constant average slope.
No mechanical pre-trend	Event-study leads before 2008 and before fiscal-rule adoption	The timing claim requires high and low-informality countries not to be on a differential adjustment path before the relevant event.
Forced adjustment, not fiscal strength	Primary-balance response after Stress	A positive primary-balance differential means sharper adjustment under constraint, not greater underlying fiscal capacity.
Primary-balance Channel	Debt-dynamics decomposition and GFC channel regressions	The clearest margin should be the primary-balance contribution; revenue and expenditure components may be noisy because adjustment can mix tax effort, arrears, and spending compression.
State dependence	Time-varying coefficients, thresholds, and state-dependent local projections	The informality effect should be stronger in stress or high-informality regimes than in pooled average specifications.

4. Data and Stylized Facts

The empirical analysis draws on an unbalanced panel of 122 non-advanced economies observed over the period 1990–2020. The sample spans all major developing regions, namely Latin America and the Caribbean, Sub-Saharan Africa, Emerging and Developing Asia, Emerging and Developing Europe, and the Middle East and North Africa, and the country composition reflects the binding constraint of shadow economy data availability rather than an arbitrary selection rule. This section describes the data sources, explains

the construction of the key variables, and documents five empirical regularities that motivate and discipline the analysis that follows.

Our primary measure of informality is the shadow economy as a percentage of official GDP, drawn from the World Bank Informal Economy Database documented by Elgin et al. (2021) and building on the estimates of Medina and Schneider (2018, 2019). We use the Dynamic General Equilibrium (DGE) estimates as our baseline measure, which model the shadow economy as the outcome of a representative agent’s optimal allocation of time between formal and informal production given the tax burden, regulatory intensity, and enforcement capacity of the state. The DGE approach has two practical advantages over the competing MIMIC (Multiple Indicators Multiple Causes) method: it produces estimates that are directly interpretable as a share of GDP and does not require the imposition of a benchmark country. The database covers 158 economies, making it the most comprehensive source of cross-country shadow economy data currently available. Elgin et al. (2021) document the dynamic general equilibrium methodology and the initial 1990–2018 release; the World Bank Informal Economy Database is updated periodically, and we use the vintage extending through 2020. As a robustness check, we also employ ILO informal employment shares from ILOSTAT, which capture labour market informality more directly but with substantially sparser temporal and cross-country coverage.

Fiscal data come from the IMF’s World Economic Outlook (WEO) database, April 2025 vintage, and include the general government primary balance, gross debt, total revenue, and total expenditure, all expressed as percentages of GDP.

We compute the effective interest rate on government debt as the ratio of implied interest payments, defined as the difference between the overall and primary balances to lagged debt, and obtain the real interest rate by subtracting consumer price inflation. The interest rate-growth differential ($r - g$), which governs the snowball effect in the debt accumulation identity, is constructed from these components. Macroeconomic controls, including real GDP growth, inflation, and trade openness are drawn from the World Development Indicators (WDI), supplemented with Penn World Table 10.1 data on human capital and total factor productivity (Feenstra et al., 2023). The replication pipeline recomputes the output gap as the percentage deviation of log real GDP per capita from a Hodrick-Prescott trend with smoothing parameter $\lambda = 6.25$, following Ravn and Uhlig (2002) for annual data; an analogous procedure yields the expenditure gap. Institutional controls used in the richer baseline and IV specifications are drawn from the Worldwide Governance Indicators (WGI) (Kaufmann and Kraay, 2024) and Polity V (Marshall and

Gur, 2020). Table 2 summarizes the data sources, vintages, and role of each input in the empirical design.

Table 2. Data Sources and Vintages

<i>Source</i>	<i>Variables used</i>	<i>Vintage / coverage</i>	<i>Role in analysis</i>
World Bank Informal Economy Database	Shadow economy, DGE and MIMIC (% GDP)	1990-2020	Primary informality measure and alternative model-based measure.
IMF WEO	Primary balance, gross debt, revenue, expenditure, fiscal balance, GDP growth, inflation, current account	April 2025 vintage; fiscal sample through 2020	Core fiscal outcomes and debt sustainability variables.
World Development Indicators	Trade openness, GDP per capita, inflation, tax revenue, sectoral and social controls	Downloaded local WDI extract	Macroeconomic controls and auxiliary validation.
Penn World Table 10.1	Real GDP per capita, human capital, TFP, employment, national accounts shares	1950-2019 source series where available	Output-gap construction and productivity controls.
Worldwide Governance Indicators / Polity V/ Chinn-Ito	Governance, political institutions, capital-account openness	Annual institutional Panels	Institutional controls, instruments, and placebo outcomes.
IMF Fiscal Rules Dataset	Rule existence and rule-type counts	1985-2024 source Panel	Fiscal-rule controls and first adoption event design.
ILOSTAT	Informal employment share	Updated 2025 extract; sparse country-year coverage	Alternative labour-market informality measure.

The sample construction follows a clear hierarchy of restrictions, reported in Table 3. We begin by excluding the economies classified as advanced by the IMF’s April 2025 WEO. We then require non-missing shadow economy data, the binding constraint that determines the sample period, along with at least one non-missing fiscal variable (primary balance or government debt) and a minimum of 10 years of data per country to ensure meaningful within-country variation for fixed effects estimation. The resulting analysis sample comprises 122 countries and 3,333 country-year observations, with realized country-level coverage ranging from 16 to 31 years depending on data availability. Table A4 in the Online Appendix lists all countries, their regional classification, and the number of years of data. Online Appendix Tables A1-A3 provide the corresponding variable-level coverage, informality-measure validation, and alternative-measure robustness checks.

Table 3. Sample Construction

<i>Sample stage</i>	<i>Observations</i>	<i>Countries</i>	<i>Years</i>
Raw WEO fiscal panel	9016	196	1980-2025
Merged panel after variable construction	9016	196	1980-2025
After excluding IMF advanced economies	7176	156	1980-2025
Require non-missing DGE shadow economy	3780	122	1990-2020
Require primary balance or debt data	3333	122	1990-2020
Final sample: at least 10 years per country	3333	122	1990-2020

Table 4 reports summary statistics for the main variables. The average shadow economy in the sample is approximately 35 percent of GDP, with a standard deviation of nearly 11 percentage points and a range from about 8 percent (at the low end, typically upper-middle-income Asian economies) to over 66 percent (in parts of Sub-Saharan Africa and Latin America). The average primary balance is close to -0.8 percent of GDP, confirming that the typical country-year in our sample runs a modest primary deficit. Government debt averages about 52 percent of GDP, but the distribution has a heavy right tail: 10 percent of observations exceed 90 percent of GDP, and the maximum reaches 600 percent. Inflation is severely right skewed by hyperinflationary episodes in several emerging markets during the 1990s, with a mean of roughly 39 percent, but the median is below 5, making the median the more informative measure of central tendency for this variable.

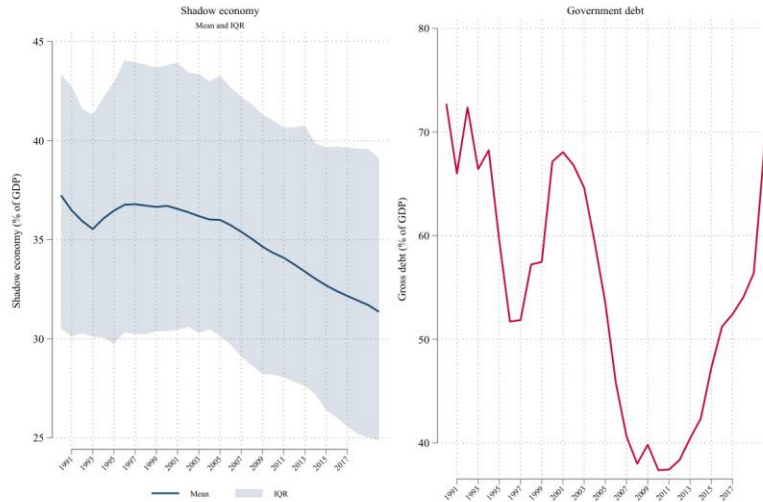
Table 4. Summary Statistics

<i>Variable</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>P25</i>	<i>Median</i>	<i>P75</i>
Primary balance, pb_{it} (% GDP)	3299	-0.84	15.16	-2.65	-0.70	1.35
Debt, d_{it} (% GDP)	3037	52.33	42.84	27.71	43.80	65.18
Government revenue, rev_{it} (% GDP)	3323	23.29	10.57	15.63	21.75	28.49
Government expenditure, exp_{it} (% GDP)	3311	26.07	17.79	18.21	24.13	31.73
Shadow economy, s_{it} (% GDP, DGE)	3333	34.79	10.74	28.25	34.59	41.81
Informal employment (% of employment, ILO)	605	57.21	25.46	39.55	57.64	79.51
Real GDP growth (%)	3327	3.91	6.25	1.79	4.12	6.29
Inflation, avg. consumer prices (%)	3291	39.04	1194.72	2.27	4.97	9.56
Output gap (HP filter, $\lambda=6.25$)	3212	0.00	0.03	-0.01	-0.00	0.01
Trade openness (% GDP)	2873	73.39	33.44	48.03	67.72	92.13
Interest rate-growth differential	2838	-38.58	1283.72	-11.09	-5.38	-1.26

Before turning to the econometric analysis, we document five salient patterns in the data that shape both our specification choices and the interpretation of the results.

The first pattern is a secular decline in informality across the developing world over the past three decades, set against a backdrop of rising and then falling government debt. Figure 1 plots the evolution of both variables over the sample period. The average shadow economy has contracted modestly but persistently since the mid-1990s, falling from roughly 37 percent of GDP to about 33 percent by 2020, a trend driven by formalization efforts, improvements in governance, and structural transformation in several middle-income countries. Government debt followed a different trajectory: it declined from the early 1990s through the mid-2000s as many developing economies benefited from the HIPC debt relief initiative and commodity booms, then reversed course after the Global Financial Crisis and has remained elevated since. The divergence between slowly declining informality and rapidly rising debt creates precisely the conditions under which the interaction between the two becomes consequential for sustainability.

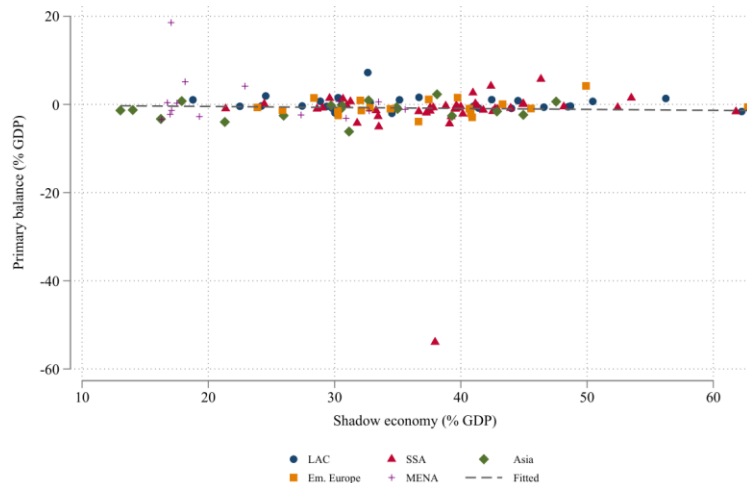
Figure 1: Evolution of Shadow Economy and Government Debt



Notes: Average across all non-advanced economies in the sample. Shaded area represents the interquartile range for the shadow economy. Source: Elgin et al. (2021); IMF WEO, April 2025.

The second regularity is a negative, but moderate, cross-country association between informality and fiscal outcomes. Figure 2 plots country-average shadow economy size against the country-average primary balance. Countries with larger shadow economies tend to run lower primary balances on average, a pattern consistent with the revenue channel emphasized in Section 3, but the scatter also shows considerable dispersion across countries and regions. We therefore treat the figure as descriptive motivation rather than as evidence of a strong unconditional relationship.

Figure 2: Shadow Economy and Primary Balance: Country Averages

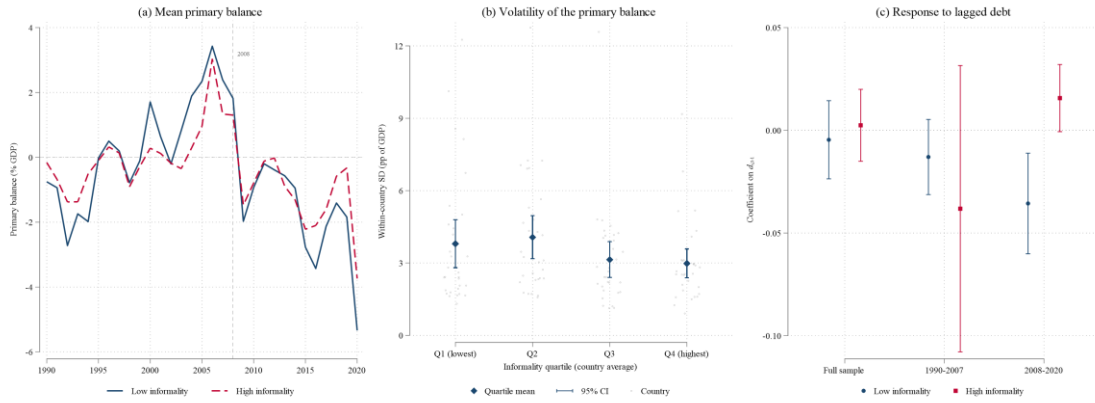


Third, informality exhibits substantial regional heterogeneity in both levels and trends. Sub-Saharan Africa has the largest shadow economy (around 39 percent of GDP), fol-

lowed closely by Emerging and Developing Europe and Latin America (around 37 percent each), while the Middle East and North Africa have the smallest (about 24 percent) and Emerging and Developing Asia lies in between (about 30 percent). This heterogeneity provides cross-sectional identifying variation but cautions against interpreting aggregate results as representative of a homogeneous developing-country experience.

Fourth, the time-series behaviour of the primary balance differs less between high- and low-informality countries than a simple fiscal-capacity story would suggest, and the differences that do appear run against it. Figure 3 splits the sample at the median country-average shadow economy (34.9 percent of GDP). Panel (a) shows that the two groups follow closely similar primary-balance paths for most of the sample period. Panel (b) shows that the within-country standard deviation of the primary balance is in fact higher among below-median countries (3.90 against 3.08 percentage points; a gap of 0.99 percentage points, $p = 0.012$, once Equatorial Guinea's extreme early-1990s observations are excluded), and that it declines across informality quartiles. This most plausibly reflects the larger government sectors of low-informality economies, which mechanically widen the range of primary balances expressed as a share of GDP, rather than greater fiscal activism. Panel (c) shows that the unconditional response of the primary balance to lagged debt is statistically indistinguishable across the two groups over the full sample (-0.005 against 0.002), and that a visible divergence emerges only after 2008, when the high-informality response turns positive and the low-informality response turns negative. We therefore do not read the median split as evidence of a weaker fiscal reaction function in high-informality countries on average. The difference that matters is concentrated around the crisis, which is the pattern the rest of the paper develops.

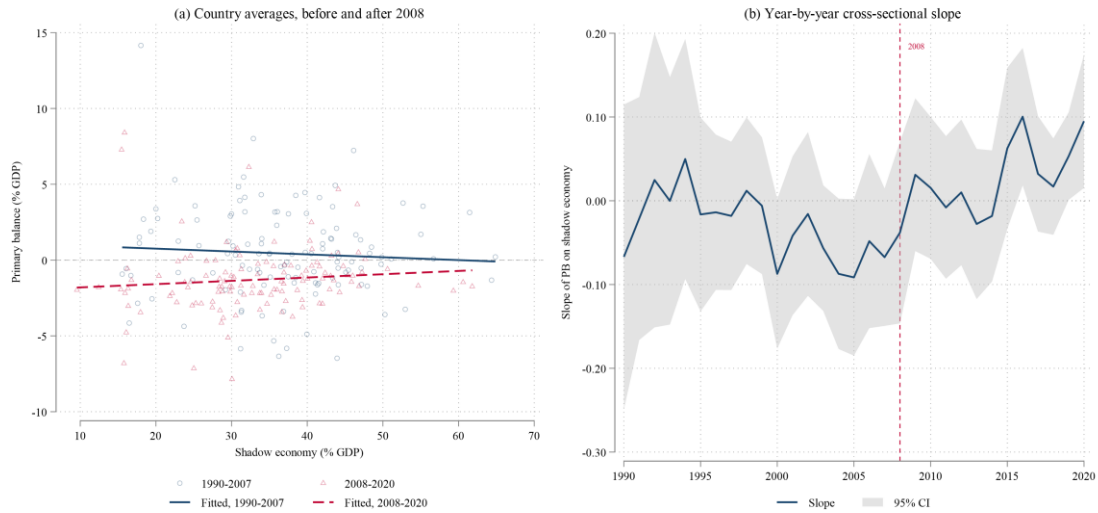
Figure 3: The Primary Balance in High- and Low-Informality Countries



Notes: Countries are split at the median country-average shadow economy (34.9 percent of GDP); the quartiles in panel (b) are formed on the same country-average measure. The primary balance is winsorized at the 1st and 99th percentiles throughout. Panel (a) reports unweighted group means by year. Panel (b) reports the within-country standard deviation of the primary balance for countries with at least ten observations; grey markers are individual countries and diamonds are quartile means with 95 percent confidence intervals. Panel (c) reports country fixed-effects estimates of the primary-balance response to lagged debt, with 95 percent confidence intervals based on standard errors clustered by country. Source: Elgin et al. (2021); IMF WEO, April 2025.

Fifth, and most consequentially for what follows, the Global Financial Crisis marks a break in the relationship between informality and the primary balance, but the break reverses that relationship rather than deepening it. Figure 4, panel (a), plots country averages separately for 1990-2007 and 2008-2020. Before 2008 the association is negative and modest (-0.036); after 2008 it is positive (0.034). The change of 0.071 is significant at the 5 percent level and survives country fixed effects, region fixed effects, and the use of unwinsorized data excluding Equatorial Guinea; among placebo break dates from 1998 to 2012, the shift is largest and most precisely estimated at 2008. Panel (b) shows that the reversal is gradual rather than instantaneous: the year-by-year cross-sectional slope is consistently negative from 2000 to 2008, crosses zero in 2009, and rises steadily thereafter. The magnitude lines up with the paper'

Figure 4: Informality and the Primary Balance before and after 2008



Notes: Panel (a) plots the country-average shadow economy against the country-average primary balance separately for 1990-2007 and 2008-2020, restricted to countries with at least five observations in the relevant period, with OLS fits. Panel (b) plots the coefficient from year-by-year cross-sectional regressions of the primary balance on the shadow economy, with 95 percent confidence intervals based on heteroskedasticity-robust standard errors. The primary balance is winsorized at the 1st and 99th percentiles. The pooled change in slope at 2008 is 0.071. Source: Elgin et al. (2021); IMF WEO, April 2025.

5. Econometric Methodology

The empirical strategy is organized as an evidence hierarchy rather than as a list of estimators. The central question is whether informality conditions fiscal adjustment when governments face debt stress. The cleanest variation comes from the common timing of the 2008-2009 Global Financial Crisis (GFC), interacted with predetermined pre-crisis informality. The remaining exercises have explicitly defined roles: mechanism tests ask which fiscal margin moves, time-varying and state-dependent models ask whether the result is activated under stress, benchmark fiscal reaction functions discipline the comparison with the standard literature, and robustness exercises probe scope and sensitivity. Table 5 summarizes this architecture.

Table 5. Empirical Architecture and Evidentiary Roles

<i>Evidence block</i>	<i>Question</i>	<i>Evidentiary role</i>	<i>Main outputs</i>
GFC exposure design	Do high-informality countries adjust differently after a common external shock?	Main shock-timing evidence; central basis for causal interpretation.	Table 8; App. Fig. A1; App. Tables A12-A17.
Mechanism tests	Which fiscal margin moves under the same exposure design?	Links the identifying variation to channels; distinguishes forced adjustment from fiscal strength.	Tables 15 and 14; App. Fig. A2.
Time variation and states	Is informality more consequential in stress or high-informality regimes?	Corroborating evidence for stress activation and regime dependence.	Figs. 4, 5, 9; Table 16.
Benchmark reaction functions	Does the average pooled fiscal reaction deliver a stable interaction coefficient?	Baseline discipline and falsification pressure; not the headline result.	Tables 10, 11, and 12; Fig. 3.
Scope and robustness	Is the result a generic institutional reform pattern, measurement artefact, or influence-driven estimate?	Boundary and sensitivity evidence.	Tables 17-18; App. Tables A18-A19; robustness tables in Section 7.

The main shock-timing design exploits the common timing of the GFC. We measure each country's mean shadow economy before 2008, then interact this predetermined exposure with post-2008 indicators. With country fixed effects and year fixed effects, identification comes from whether countries with different pre-crisis informality experienced different fiscal adjustment after the same global shock. With region-year fixed effects, the comparison is narrower: countries are compared only against others in the same broad region facing the same region-specific annual shock. Formally, the estimating equation is:

$$pb_{it} = \lambda_i + \tau_t + \psi(\bar{s}_{i,1990-2007} \times Post_t) + \kappa d_{it-1} + \eta' X_{it} + u_{it}, \quad (10)$$

where pb_{it} is the primary balance, $\bar{s}_{i,1990-2007}$ is measured before the crisis, and $Post_t$ equals one from 2008 onward. The identifying assumption is not that pre-crisis informality is randomly assigned. It is that, absent the common shock, high- and low-informality countries would not have experienced a discrete differential break in primary-balance behaviour exactly after 2008. We probe this assumption with event-study leads and lags, placebo break years, placebo outcomes, alternative post-crisis windows, pre-crisis control interactions, and leave-one-region and leave-one-large-country sensitivity checks.

To connect the identifying variation to the paper's mechanism, we estimate the same GFC exposure design on channel outcomes:

$$y_{it}^{(m)} = \lambda_i^{(m)} + \tau_t^{(m)} + \psi_m(\bar{s}_{i,1990-2007} \times Post_t) + \kappa_m d_{it-1} + \eta_m' X_{it} + u_{it}^{(m)}, \quad (11)$$

where $y_{it}^{(m)}$ includes the primary balance, government revenue, tax revenue, government expenditure, GDP growth, the interest-growth differential, and the change in debt. This exercise does not replace the accounting decomposition; it asks which component moves when the main predetermined-exposure design is applied directly to mechanism outcomes.

To reduce dependence on the GFC alone, we estimate a separate fiscal-rule adoption design. This exercise identifies each country's first observed transition from no fiscal rule to any fiscal rule, excludes countries already under a rule at the first observation, and measures informality using the five-year pre-adoption average. The adoption sample is restricted to countries with at least three pre-adoption informality observations. We compare post-adoption primary-balance changes across high and low-informality adopters, using never-treated countries as controls, and report both difference-in-differences specifications and an event study with the year before adoption as the omitted category. Because fiscal rules are themselves policy choices, this design is not as clean as the common-shock design. Its role is a scope check: it asks whether the informality pattern is reproduced around a non-GFC fiscal-institution event and whether any such pattern is preceded by differential trends.

The benchmark specifications embed informality in the standard Bohn (1998) fiscal reaction function introduced in Equation (3). In the pooled panel, the coefficient ρ captures the average fiscal response to lagged debt, while δ on the informality–debt interaction captures whether informality changes that response. A negative δ implies that informality weakens the sustainability condition because the marginal fiscal response to debt, $\rho + \delta s_{it}$, declines with the size of the shadow economy. In the baseline specifications, X_{it} includes the output gap, expenditure gap, and trade openness; richer specifications add log GDP per capita and institutional controls. These pooled specifications establish the benchmark against which the shock-timing evidence is interpreted, but they are not the paper's main source of identification.

The static benchmark constrains all coefficients to be constant over a 30-year period that includes several global and regional shocks. We relax that restriction using three time-varying approaches. First, we estimate a parametric time-trend interaction model:

$$pb_{it} = (\rho_0 + \rho_1 t + \rho_2 t^2) d_{it-1} + (\beta_0 + \beta_1 t) s_{it} + (\delta_0 + \delta_1 t + \delta_2 t^2) (s_{it} \times d_{it-1}) + \gamma' X_{it} + \alpha_i + \varepsilon_{it}. \quad (12)$$

The implied path $\delta(t) = \delta_0 + \delta_1 t + \delta_2 t^2$ provides a smooth approximation to time variation in the informality–debt interaction. Second, we estimate rolling-window panel models on overlapping 7-year, 10-year, and 15-year windows, producing sequences of $\hat{\rho}_{(t)}$, $\hat{\beta}_{(t)}$ and $\hat{\delta}_{(t)}$. Third, we use a two-step procedure that combines year-by-year cross-sectional estimates with Kalman smoothing:

$$\theta_t = \theta_{t-1} + u_t, \quad u_t \sim N(0, Q), \quad (13)$$

$$\hat{\theta}_t = \theta_t + v_t, \quad v_t \sim N(0, R_t), \quad (14)$$

where $R_t = \hat{\sigma}_t^2$ is the measurement error variance from the first-step cross-sectional estimate. The Kalman smoother extracts persistent movements from noisy annual estimates and is used as corroborating visual evidence rather than as a standalone structural model.

The debt dynamics decomposition provides the accounting counterpart to the mechanism regressions. Rather than estimating only the composite fiscal reaction, we ask how informality feeds through each component of the debt accumulation identity. For each component $k \in \{\Delta d, \text{snowball}, pb, sfa, \text{revenue}, \text{expenditure}, g\}$, we estimate:

$$y_{it}^{(k)} = \beta^{(k)} s_{it} + \gamma^{(k)'} X_{it} + \alpha_i^{(k)} + \mu_t^{(k)} + \varepsilon_{it}^{(k)}, \quad (15)$$

with country and year fixed effects. The coefficient $\beta^{(k)}$ measures the partial association between informality and each debt-dynamics component, conditional on controls and two-way fixed effects.

We use three additional exercises to examine nonlinear and state-dependent implications. The nonlinear fiscal reaction function follows Ghosh et al. (2013) and estimates a cubic polynomial in debt whose coefficients depend on informality:

$$pb_{it} = a_1 d_{it-1} + a_2 \frac{d_{it-1}^2}{100} + a_3 \frac{d_{it-1}^3}{10000} + b_0 s_{it} + b_1 s_{it} d_{it-1} + b_2 s_{it} \frac{d_{it-1}^2}{100} + b_3 s_{it} \frac{d_{it-1}^3}{10000} + \gamma' X_{it} + \alpha_i + \mu_t + \varepsilon_{it}. \quad (16)$$

The fitted values trace an informality-conditional fiscal reaction function, and the implied debt limit is the point at which this reaction no longer exceeds the debt-stabilizing

primary balance line. We treat this as a policy illustration because the estimated debt-limit schedule is model-sensitive. The threshold panel model tests for a discrete break in the fiscal reaction at a critical level of informality:

$$pb_{it} = \rho_1 d_{it-1} \cdot 1(s_{it} \leq \hat{\gamma}) + \rho_2 d_{it-1} \cdot 1(s_{it} > \hat{\gamma}) + \beta' X_{it} + \alpha_i + \varepsilon_{it}. \quad (17)$$

Finally, local projections in the spirit of Jordà (2005) trace the dynamic response of fiscal variables to informality shocks:

$$y_{it+h} - y_{it-1} = \beta_h \text{shock}_{it} + \phi' W_{it} + \alpha_i^{(h)} + \mu_t^{(h)} + \varepsilon_{it}^{(h)}, \quad h = 0, 1, \dots, H, \quad (18)$$

where the shock is defined as the deviation of informality from its country-specific moving average. State-dependent versions allow impulse responses to differ between high- and low-informality regimes.

The remaining estimators play supporting robustness roles. Alternative-measure exercises replace the DGE shadow-economy measure with MIMIC, ILO informal employment, and combined measures. Instrumental-variable specifications use lagged regulatory quality and agricultural employment share as external instruments, while system GMM specifications (Arellano and Bond, 1991; Blundell and Bond, 1998; Roodman, 2009) use deeper lags as internal instruments with deliberately parsimonious instrument counts. These estimators are useful for checking whether the pooled interaction survives alternative identifying assumptions, but they are not treated as substitutes for the shock-timing design.

Our claim is therefore deliberately narrower than a universal causal slope. We do not identify a single structural effect of informality with invariant sign and magnitude across specifications. Rather, we show that higher informality conditions how developing economies adjust under debt stress, especially around an externally timed shock, and that this conditioning is visible across crisis-timing, mechanism, time-varying, and state-dependent evidence. A positive post-2008 primary-balance differential should not be read as stronger fiscal capacity; in this architecture, it is evidence of tighter adjustment and reduced room for manoeuvre once the common shock materializes.

6. Results

The results follow the evidence hierarchy laid out in Table 5: the GFC exposure design is the central shock-timing evidence; mechanism and time-varying exercises explain and corroborate that result; pooled fiscal reaction functions and robustness exercises discipline its scope. Table 6 provides an estimate-level roadmap, recording the key parameter, its sign or qualitative direction, its statistical significance, and the table or figure where it is reported. Read as a whole, the roadmap shows that the paper’s strongest results are not the pooled average interactions but the stress-conditioned timing, mechanism, and state-dependent evidence.

Table 6. Summary of Empirical Approaches and Key Results

<i>Approach</i>	<i>Key parameter</i>	<i>Sign</i>	<i>Signif.</i>	<i>Source</i>
<i>Panel A: Static specifications</i>				
Baseline panel FE	δ (SE $\times$ debt, centered)	mixed		Table 10
System GMM	δ (SE $\times$ debt, centered)	mixed		Table 11
IV – FE/ robust GMM	δ (SE $\times$ debt)	≈ 0		Table 20
With fiscal rules control	δ (SE $\times$ debt, centered)	≈ 0		Table 12
<i>Panel B: Time-varying specification</i>				
Kalman-smoothed TVP	δ_t trend	$\searrow$		Fig. 4
Rolling window (7/ 10/ 15yr)	$\delta_{(t)}$ trend	$\searrow$		Fig. 5
Parametric (quadratic time)	SE $\times$ debt $\times$ time terms	Spec.-dep.	*	Table 13
<i>Panel C: Channels and nonlinearity</i>				
Debt dynamics decomposition	SE $\rightarrow$ PB contribution	–	**	Table 14
GFC mechanism channels	pre-GFC SE $\times$ post-2008	PB + / revenue +	***	Table 15
Nonlinear FRF / fiscal space	Debt-limit mapping	non-monotone		App. Fig. A6
Threshold model (27% GDP)	ρ_{high} vs. ρ_{low}	$>$	**/**	Table 16
<i>Panel D: Dynamic responses</i>				
Local projections	Debt IRF to SE shock	–	**	Fig. 8
State-dependent LP	High-SE amplification	$>$		Fig. 9
<i>Panel E: Robustness</i>				
High-standard GFC checks	pre-GFC SE $\times$ post-2008	+	**/ ***	Table 17-18
ILO informal employment	δ (ILO $\times$ debt)	–	**	Table 19
Regional subsamples	δ by region	mixed		Table A6
Fiscal-rule adoption event	pre-rule SE $\times$ post-adoption	Short-run +	*	App. Tables A18-A19
Pre- vs. post-GFC split	Interaction shifts after 2008	mixed	**	Table A9
Alternative specifications (7)	δ range	≈ 0		Table A8

Notes: Significance: *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively the “Sign” column reports the sign of the key parameter or the direction of the trend ($\searrow$ = increasingly negative over time). SE = shadow economy.

6.1. Main Shock-Timing Evidence

Table 7 distills the preferred evidence from the larger set of exercises. It separates the paper’s most stable findings from results that are useful but more model sensitive and maps them back to the theory’s distinction between fiscal capacity and forced adjustment. Three conclusions emerge. First, the strongest signal is shock conditioned rather than static: the GFC exposure design, time-varying estimates, and state-dependent exercises

point to a more adverse fiscal role for informality around major stress episodes. Second, the crisis-timing design and the mechanism tables indicate that the primary balance is the key adjustment margin. Third, nonlinear debt-limit calculations are informative as supporting evidence, but they are not precise enough to serve as the paper’s headline quantitative result.

Table 7. Core Empirical Takeaways

<i>Dimension</i>	<i>Preferred Evidence</i>	<i>Main Takeaway</i>
Average pooled Interaction	Tables 10, 11, and 20	The average informality–debt interaction is specification-sensitive and often imprecisely estimated; it should not carry the paper on its own.
Time variation	Figures 6 and 7; Table 13	Informality becomes more fiscally costly over time, with the deterioration most visible around the 2008–2009 break and in the nonparametric exercises.
Shock-timing Identification	Tables 8 and 17; App. Fig. A1	Countries with higher pre-crisis informality follow a distinct post-2008 primary-balance path, with no obvious differential pre-trend before the common shock and strong specification/influence robustness.
Beyond-GFC policy event	App. Tables A18–A19; App. Fig. A5	First fiscal-rule adoption shows no rejected differential pre-trend but only a short-lived adoption-year effect, supporting scope conditions rather than a second headline causal effect.
Transmission Channel	Tables 14 and 15	The primary balance is the main adjustment margin. The GFC-channel table links this margin to the paper’s shock-timing design and shows weaker evidence for expenditure, growth, or snowball channels.
Regime dependence	Table 16; Figure 11	Fiscal effects differ across high- and low-informality states, even if the threshold coefficients are not monotone in the simplest sense.
Policy reading	Table 12; Figure 9; App. Fig. A6	Informality should be treated as a structural constraint on fiscal capacity. Debt-limit calibration is useful only as supplementary, model-sensitive evidence.

Table 8 presents the paper’s main shock-timing evidence. The design measures each country’s average shadow economy before 2008 and asks whether countries with higher predetermined informality followed different post-2008 primary-balance paths after absorbing country effects and common shocks. Column (1) uses a binary high-exposure indicator, Column (2) uses the continuous standardized exposure, Column (3) adds region-year fixed effects, so identification comes from within-region differences in post-crisis adjustment, and Column (4) adds the full set of predetermined pre-crisis exposure controls. The post-2008 differential is positive and statistically significant in Columns (1) – (3), ranging from 0.615 to 1.476 percentage points of GDP, but it attenuates to 0.294 and is no longer significant in the fully saturated Column (4). Accordingly, we treat the reduced-form pattern, rather than the saturated point estimate, as the object of inference. Online Appendix Figure A1 and Table A11 cannot reject parallel pre-trends before 2008 (joint test $p = 0.442$), although that test has limited power; the post-crisis coefficients turn positive and become statistically significant in several years after the shock. The post-2008 break is moreover robust to netting out a differential linear pre-trend, which is

itself small and statistically insignificant (Table 22), and to Rambachan and Roth (2023) honest difference-in-differences sensitivity bounds. Because the dependent variable is the primary balance, the positive coefficient indicates that countries with higher pre-crisis informality undertook stronger fiscal adjustment after 2008, reflected in larger surpluses or smaller deficits relative to the control group. This should be interpreted as differential adjustment to the crisis, not as evidence that informality improves fiscal capacity. A more plausible reading is that more informal economies faced tighter post-crisis financing constraints, which forced sharper fiscal consolidation. This post-2008 level differential (ψ in Equation (10)) and the pooled debt-response slope (δ in Equation (3)) are distinct objects: the crisis design identifies a one-time shift in the level of the primary balance for high-informality economies, not the average sensitivity of the primary balance to debt. A positive ψ alongside a weak or imprecise pooled δ is therefore internally consistent rather than contradictory.

The auxiliary design checks sharpen and qualify this interpretation. In Online Appendix Table A12, the coefficient on pre-crisis informality remains positive when pre-crisis fiscal, macroeconomic, and institutional control interactions are added, but, as Column (4) of the main table now shows, it attenuates and is no longer statistically significant once the full control set and year fixed effects are included. We therefore rest the reduced-form crisis-timing claim on the randomization-inference and leave-one-country-out diagnostics rather than on the saturated-control point estimate; the significantly negative coefficient on the pre-crisis current-account interaction (-1.025) is itself consistent with the external-financing reading developed below. Table A14 shows no significant response for slow-moving institutional or capital-account placebo outcomes. Table A16 shows that the result is not driven by a single region, although the estimate is weaker when the Middle East and North Africa are omitted; Table A17 shows that it is not driven by any one large country. Table A13 indicates that the positive differential is strongest for persistent post-2009 and post-2010 windows rather than for a short 2008–2012 burst. Finally, Table A15 shows that pre-2008 placebo break years do not reproduce the same positive post-GFC pattern: earlier pseudo-breaks are negative in 2001 and 2003 and fade by 2005. This does not make the design a randomized experiment, but it makes the core claim more specific: the 2008 shock marks a change in the direction of fiscal adjustment for high-informality economies rather than simply continuing a positive pre-existing trend.

Table 8. Identification: Differential Exposure to the Global Financial Crisis

	(1) <i>Binary Exposure</i>	(2) <i>Continuous Exposure</i>	(3) <i>Continuous + Region-Year FE</i>	(4) <i>+ Pre-Crisis Controls</i>
High pre-crisis informality $\times Post_t$	1.476** (0.587)			
Pre-crisis s (std.) $\times Post_t$		0.758** (0.297)	0.615** (0.260)	0.294 (0.282)
Debt, $d_{i,t-1}$ (% GDP)	0.014* (0.007)	0.013* (0.007)	0.013 (0.008)	0.015* (0.009)
Observations	2395	2395	2395	2326
Countries	112.000	112.000	112.000	109.000
Within R-sq	0.218	0.219	0.304	0.242

Notes: Standard errors in parentheses. Dependent variable: primary balance (% of GDP). Post = 1 for years 2008 onwards. Binary exposure = above-median mean shadow economy during 1990-2007. Column (3) absorbs region-specific shocks with region-year fixed effects. Column (4) adds the full set of standardised pre-crisis exposure interactions (fiscal, macroeconomic, institutional, and resource) with year fixed effects. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

The positive post-2008 differential is most plausibly read as forced adjustment under tighter financing rather than as evidence of stronger fiscal capacity. To test this mechanism directly, Table 9 re-estimates the exposure design with predetermined pre-crisis reliance on IMF credit (use of IMF credit, % of GDP) and external-debt burden (external debt, % of GNI), each interacted with $Post_t$, a triple interaction of informality with external debt and $Post_t$, and a split at the median pre-crisis external-debt burden. The informality differential is robust to these financing controls (0.69–0.72, $p < 0.05$) and is markedly larger in high-external-debt economies (1.08, $p < 0.01$) than in low-debt ones (0.46, insignificant), while the informality $\times$ external-debt $\times Post_t$ triple interaction is positive (0.578, $p < 0.10$). The post-2008 adjustment is thus concentrated precisely where external financing tightened, providing direct evidence for the constrained-adjustment reading rather than for any notion that informality enhances fiscal capacity.

Table 9. Financing-Constraint Channel in the GFC Exposure Design

	(1) + IMF credit	(2) + Ext. debt	(3) Both	(4) Triple	(5) Low Constant	(6) High constant
Pre-crisis s (std.) $\times Post_t$	0.691** (2.77)	0.720** (0.283)	0.720** (0.277)	0.833*** (0.230)	0.462 (0.394)	1.080*** (0.311)
Pre-crisis IMF-credit reliance (std.) $\times Post_t$	-0.045 (0.392)		-0.001 (0.394)			
Pre-crisis external debt (std.) $\times Post_t$		-0.158 (0.333)	-0.157 (0.331)	-0.316 (0.352)		
$s \times \text{external debt} \times Post_t$				0.578* (0.301)		
Debt, $d_{i,t-1}$ (% GDP)	0.016* (0.008)	0.016* (0.008)	0.016* (0.009)	0.015* (0.008)	0.036** (0.015)	0.013 (0.009)
Observations	1897	1897	1897	1897	1897	1897
Countries	91.000	90.000	90.000	90.000	46.000	44.000
Within R-sq	0.252	0.252	0.252	0.255	0.252	0.288

Notes: Standard errors in parentheses. Dependent variable: primary balance (% of GDP). Pre-crisis exposures are 1990-2007 means, standardised, interacted with post-2008. IMF-credit reliance = use of IMF credit (% GDP); external debt = external debt stocks (% GNI). Cols (5)-(6) split the sample at the median pre-crisis external-debt burden. Coverage varies: IMF-credit and external-debt series exist only for World Bank IDS (developing-debtor) economies. All columns include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

The non-GFC fiscal-rule adoption design in Online Appendix Tables A18-A19 and Figure A5 provides a stricter scope check. The design exploits the first observed adoption of any fiscal rule, excludes countries already under a rule at the start of the sample, and compares 58 adopting countries with sufficient pre-adoption informality data to 58 never-treated countries. The difference-in-differences estimates do not show a persistent informality differential after rule adoption: the binary exposure coefficient is 0.452, while the continuous exposure coefficient ranges from -0.545 with region-year fixed effects to 0.199 with pre-rule controls. The event study does not reject parallel pre-trends ($p = 0.237$), but only the adoption-year coefficient is marginally positive, and the later coefficients are imprecise. This exercise therefore strengthens the identification discussion by showing what the GFC result is not: it is not simply a generic fiscal-rule adoption pattern or a general post-institutional-reform trend.

Taken together, Figures 6 and 7, Table 8, the fiscal-rule adoption check, and Tables 14–15 point to a common interpretation. Informality does not appear primarily as a stable average interaction effect; rather, it shapes the pattern of adjustment in periods of stress. Around the 2008–2009 break, countries with higher pre-crisis informality shift onto a statistically distinct primary-balance path, a pattern that is not replicated in the non-GFC fiscal-rule exercise. The mechanism results further indicate that the primary balance is the main adjustment margin. Overall, this evidence is more consistent with tighter crisis-time adjustment and more limited fiscal space in high-informality economies than with any notion that informality mechanically enhances fiscal capacity.

6.2. Benchmark and Pooled Fiscal Reaction Functions

Table 10 reports the baseline panel fixed effects estimates. We present these pooled specifications as benchmarks rather than as the paper's central contribution. Column (1) presents the simple Bohn (1998) specification: the coefficient on lagged debt is -0.060 , which is negative and imprecisely estimated in the unconditional regression, reflecting the heterogeneity across 122 countries. Column (2) adds cyclical controls, with the expenditure gap entering at -58.6 and the output gap remaining imprecisely estimated. Column (3) introduces the shadow economy directly: its coefficient is -1.380 , again imprecise. Columns (4)–(6) add the centered shadow economy–debt interaction. In Column (4), the interaction is negative (-0.010), but after adding trade openness in Column (5) it shrinks to 0.000 , and in Column (6) it is -0.001 . The more stable features of the table are the negative expenditure-gap coefficient and the positive direct association between the shadow economy and the primary balance in the richer specifications, not a precisely estimated pooled interaction effect.

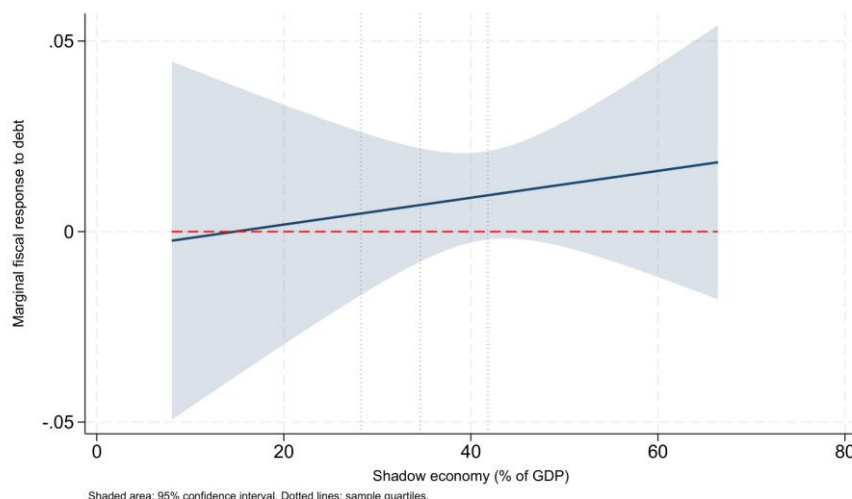
Table 10. Baseline Fiscal Reaction Function Estimates

	(1)	(2)	(3)	(4)	(5)	(6)
Debt, d_{it-1} (% GDP)	-0.060 (0.068)	-0.059 (0.068)	-0.026 (0.029)	0.021 (0.028)	0.007 (0.008)	0.016 (0.013)
Shadow economy, s_{it} (% GDP, DGE)			-1.380 (1.199)	-1.172 (0.988)	0.320*** (0.072)	0.402*** (0.103)
$(s_{it} - \bar{s})(d_{it-1} - \bar{d})$				-0.010 (0.007)	0.000 (0.001)	-0.001 (0.001)
Output gap (HP filter, $\lambda = 6.25$)		15.451 (13.538)	15.570 (12.870)	12.806 (13.658)	6.016 (9.375)	6.304 (8.204)
Government expenditure gap (HP filter)		-58.606* (32.341)	-56.023* (29.310)	-54.400** (27.409)	-19.186*** (2.712)	-16.101*** (4.300)
Trade openness (% GDP)					0.048*** (0.013)	0.060** (0.027)
WGI: Regulatory Quality						3.350 ** (1.292)
Polity2 score (-10 to +10)						0.070 (0.135)
Observations	2901	2780	2780	2780	2395	850
Countries	122.000	122.000	122.000	122.000	112.000	48.000
Within R-sq	0.016	0.116	0.192	0.224	0.139	0.188

Notes: Standard errors in parentheses. Panel fixed effects with clustered standard errors. Dependent variable: Primary balance, pb_{it} (% GDP). Centered interaction is (shadow economy minus mean) times (lagged debt minus mean). *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

The interaction coefficient therefore warrants careful interpretation. Because debt and the shadow economy are centred before interacting, the coefficient on lagged debt gives the marginal fiscal response at the sample mean of informality, and the interaction term governs how that response changes as informality moves away from that mean.

Figure 5: Marginal Fiscal Response to Debt as a Function of Informality



Notes: Marginal effect of debt on the primary balance from the centred-interaction fixed effects specification used to generate the figure. Shaded area: 95% confidence interval computed using the delta method. Vertical dotted lines mark the 25th, 50th, and 75th percentiles of the shadow economy distribution.

Figure 5 plots this marginal effect for the centred-interaction specification used to generate the figure. The estimated slope is shallow, and the confidence bands are wide, so the figure is best read as evidence of substantial uncertainty around the pooled interaction rather than a tightly estimated monotone relationship.

Table 11 reports system GMM estimates with collapsed instruments (lags 2–3), yielding 9-16 instruments, a deliberately parsimonious instrument count. The lagged dependent variable enters at 0.62 in the preferred specification, confirming substantial fiscal persistence. But the interaction evidence remains mixed: it is negative in Column (3) and slightly positive in Column (4), and in both cases it is imprecisely estimated. The preferred specification combines a defensible Hansen p-value of 0.263 with an AR(2) p-value of 0.048, so the GMM results are informative but should be interpreted cautiously.

Table 11. Dynamic Fiscal Reaction Function: System GMM

	(1)	(2)	(3)	(4)
Primary balance, $pb_{i,t-1}$ (% GDP)	1.088*** (0.032)	1.087*** (0.035)	0.982*** (0.060)	0.621*** (0.069)
Debt, $d_{i,t-1}$ (% GDP)	-0.028 (0.039)	0.007 (0.022)	0.009 (0.028)	0.022*** (0.007)
Shadow economy, s_{it} (% GDP, DGE)		-0.489 (0.368)	-0.463 (0.414)	-0.013 (0.039)
$(s_{it} - \bar{s})(d_{i,t-1} - \bar{d})$			-0.004 (0.003)	0.001 (0.001)
Output gap (HP filter, $\lambda = 6.25$)	-43.754 (38.509)	-12.959 (21.288)	-12.648 (21.223)	14.766*** (5.518)
Government expenditure gap (HP filter)	-47.922*** (17.733)	-38.206*** (11.808)	-39.599*** (13.154)	-18.479*** (3.300)
Trade openness (% GDP)				0.008 *** (0.003)
Observations	2759	2759	2759	2378
Hansen p-value	0.000	0.002	0.003	0.263
AR(2) p-value	0.322	0.315	0.312	0.048
N instruments	9.000	12.000	15.000	16.000
Countries	122.000	122.000	122.000	112.000

Notes: Standard errors in parentheses. Two-step System GMM, Windmeijer-corrected SE. Instruments collapsed. GMM instruments: t-2 to t-3 lags of endogenous variables. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

The fiscal rules control in Table 12 reinforces that caution: adding a fiscal-rule indicator or a rule-strength index leaves the interaction essentially unchanged and close to zero, suggesting that fiscal frameworks do not resolve the pooled interaction ambiguity. These tables are therefore best read as benchmark and sensitivity evidence; they do not overturn the paper's stronger dynamic and crisis-timing results.

Table 12. Fiscal Reaction Function with Fiscal Rules Control

	(1) <i>Baseline</i>	(2) <i>+ Rule dummy</i>	(3) <i>+ Rule strength</i>
Debt, $d_{i,t-1}$ (% GDP)	0.007 (0.008)	0.007 (0.008)	0.007 (0.008)
Shadow economy, s_{it} (% GDP, DGE)	0.320*** (0.072)	0.337*** (0.077)	0.337*** (0.078)
$(s_{it} - \bar{s})(d_{i,t-1} - \bar{d})$	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
(max) has_fiscal_rule		0.468 (0.362)	
(max) fiscal_rule_strength			0.212 (0.175)
Output gap (HP filter, $\lambda = 6.25$)	6.016 (9.375)	5.993 (9.376)	6.004 (9.374)
Government expenditure gap (HP filter)	-19.186*** (2.712)	-19.147*** (2.702)	-19.147*** (2.700)
Trade openness (% GDP)	0.048*** (0.013)	0.048*** (0.013)	0.047*** (0.013)
Observations	2395	2395	2395
Countries	112.000	112.000	112.000
Within R-sq	0.139	0.140	0.140

Notes: Standard errors in parentheses. Panel fixed effects with clustered standard errors. Dependent variable: primary balance (% GDP). *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

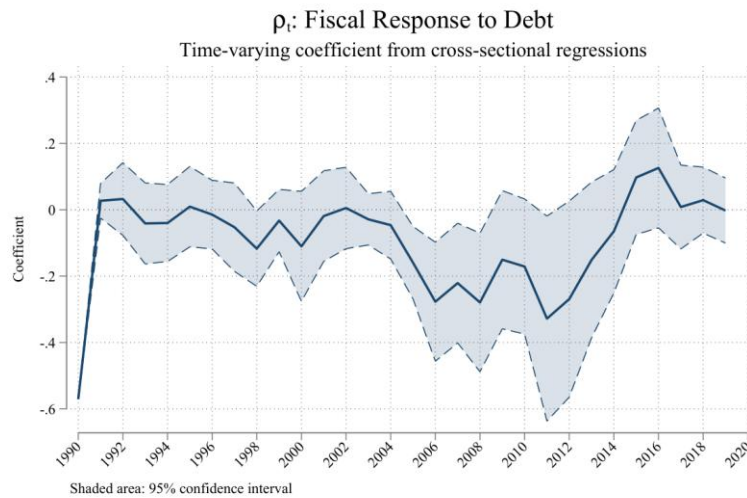
The static estimates, informative as they are, constrain all coefficients to be constant over a 30-year period that spans the Asian financial crisis, the commodity super cycle of the 2000s, the Global Financial Crisis, and the initial shock of the COVID-19 pandemic.

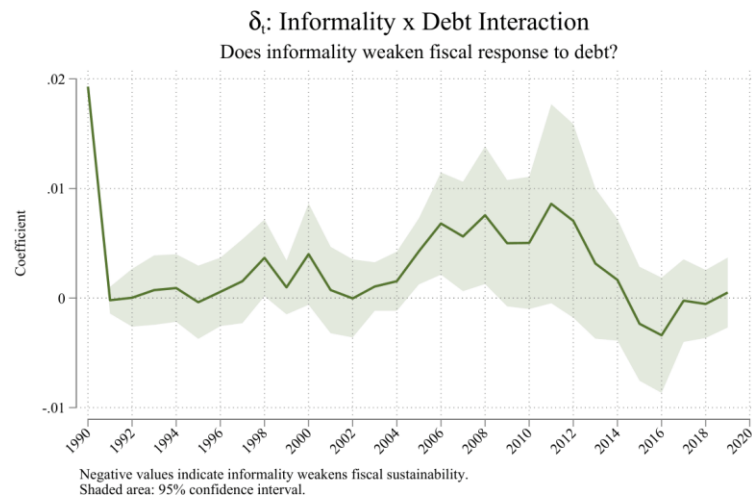
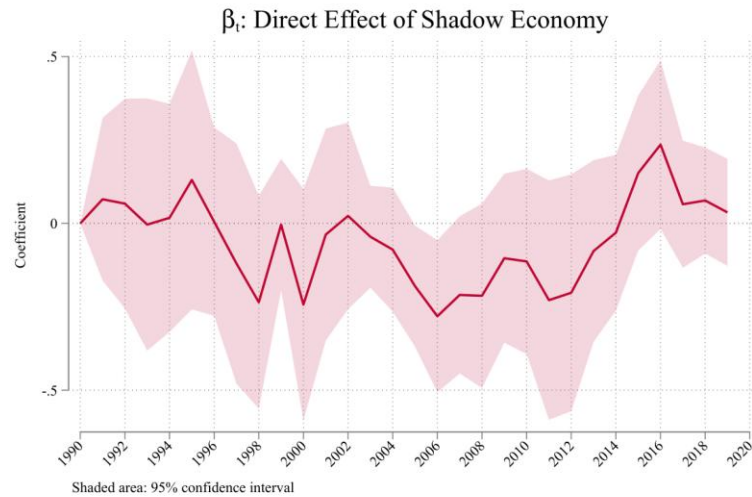
The time-varying analysis relaxes this constraint and reveals dynamics that the pooled regressions conceal.

6.3. Time Variation

Figure 6 displays the Kalman-smoothed coefficient paths from the two-step TVP procedure. The top panel shows the fiscal response to debt (ρ_t), which fluctuates but remains positive through most of the sample. The middle panel traces the direct effect of the shadow economy on the primary balance (β_t), which fluctuates around zero with no clear persistent trend. The bottom panel shows that the time-varying interaction coefficient (δ_t) is close to zero or slightly positive for most of the sample and turns negative in the mid-2010s. The main value of the figure is therefore to highlight a deterioration in the interaction around major global shocks rather than to claim a precisely estimated coefficient in every year.

Figure 6: Time-Varying Fiscal Reaction Function Coefficients





Notes: Year-by-year OLS estimates (dashed) with 95% confidence bands and Kalman-smoothed paths (solid). Top: fiscal response to debt (ρ_t). Middle: direct effect of shadow economy (β_t). Bottom: interaction between shadow economy and debt (δ_t).

The rolling-window estimates in Figure 7 broadly corroborate this finding. The 7-year, 10-year, and 15-year windows produce qualitatively similar movements in the interaction coefficient, with the shorter windows capturing the post-GFC deterioration more sharply and the longer windows smoothing it out. As with the Kalman smoothed results, the rolling estimates are more informative about evolving patterns than about a single stable pooled magnitude.

Figure 7: Rolling-Window Fiscal Reaction Function Coefficients

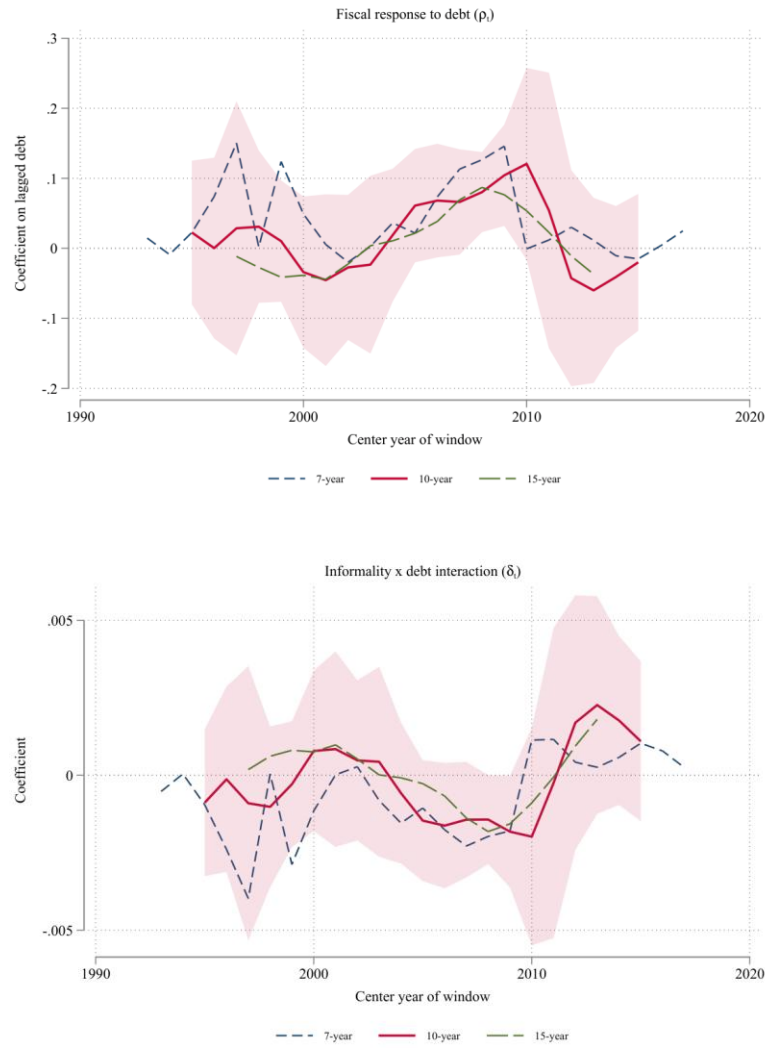
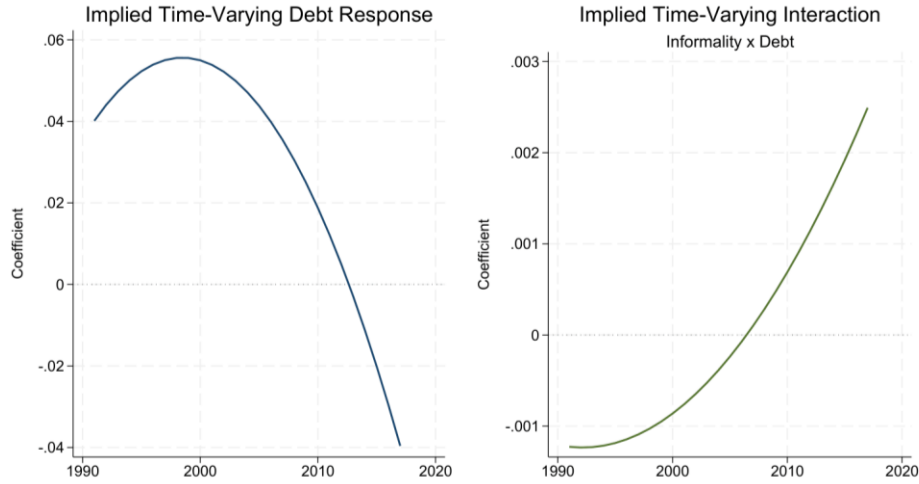


Table 13 and Figure 8 present the parametric counterpart. In the parsimonious specification of Column (3), the triple interaction $s_{it} \times d_{i,t-1} \times t$ enters at 0.0025 ($p < 0.05$), while the quadratic term is -0.0001 ($p < 0.10$), pointing to time variation in the interaction. In the fully controlled Column (4), however, those time-interaction terms are effectively zero. The parametric evidence should therefore be read as suggestive rather than definitive, albeit broadly consistent with the visual deterioration around the post-2008 period in the nonparametric exercises.

Table 13. Fiscal Reaction Function with Parametric Time Variation

	(1)	(2)	(3)	(4)
Debt, $d_{i,t-1}$ (% GDP)	0.3798 (0.2893)	0.3713 (0.2414)	0.6395* (0.3290)	0.0401 (0.0313)
$d_{i,t-1} \times t$	-0.0034 (0.0024)	0.0276* (0.0156)	-0.0666* (0.0369)	0.0041 (0.0044)
$d_{i,t-1} \times t^2$		-0.0011* (0.0006)	0.0015 (0.0009)	-0.0003* (0.0001)
Shadow economy, s_{it} (% GDP, DGE)	-0.9477 (0.7914)	-0.9007 (0.6671)	-1.1115* (0.6007)	0.3905*** (0.1188)
$s_{it} \times t$			-0.0194** (0.0089)	-0.0063*** (0.0021)
$s_{it} \times d_{i,t-1}$	-0.0093 (0.0073)	-0.0130 (0.0081)	-0.0231*** (0.0106)	-0.0012 (0.0009)
$s_{it} \times d_{i,t-1} \times t$			0.0025** (0.0012)	-0.0000 (0.0001)
$s_{it} \times d_{i,t-1} \times t^2$			-0.0001* (0.0000)	0.0000 (0.0000)
Observations	2780	2780	2780	2365
Countries	122.000	122.000	122.000	122.000
Within R-sq	0.2309	0.3073	0.4027	0.2131

Notes: Standard errors in parentheses. Panel FE with clustered SE. Time trend: $t = \text{year} - 1991$. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

Figure 8: Implied Time-Varying Interaction Coefficient from Parametric Specification

Notes: Implied path of δ_t from the quadratic time-interaction specification.

6.4. Mechanisms, Nonlinearities and Dynamic Responses

The mechanism evidence has two layers. The debt dynamics decomposition in Table 14 first identifies the average within-country channels through which informality operates. A one-percentage-point increase in the shadow economy is associated with a -0.264 ($p < 0.10$) change in the debt ratio, a -0.207 ($p < 0.05$) contribution from the primary balance, and a 0.234 ($p < 0.01$) increase in GDP growth. Interpreting the primary-balance

channel requires attention to the accounting convention: the decomposition uses the primary-balance contribution to debt change, defined as primary balance. A negative coefficient therefore means that the primary balance moves in a more debt-reducing direction. Read alongside the crisis-timing design, the natural interpretation is sharper fiscal adjustment under stress rather than stronger underlying fiscal comfort. The revenue coefficient is positive and insignificant, while the expenditure coefficient is negative and insignificant, so the cleanest result in the decomposition is that the primary balance is the main adjustment margin rather than a precisely isolated revenue channel. The positive growth coefficient may appear counterintuitive but is consistent with the dual-economy literature: informal activity contributes to measured GDP even as it escapes the tax net, so that the fiscal constraint from informality operates through the gap between economic activity and taxable activity rather than through aggregate output per se. The snowball and stock-flow-adjustment columns should be read especially cautiously because hyperinflation episodes and debt restructurings create extreme observations in the implied interest rate-growth differential and in residual debt changes.

Table 14. Debt Dynamics Effect of Informality on Each Component

	(1) <i>Debt change</i>	(2) <i>Snowball</i>	(3) <i>PB contrib</i>	(4) <i>SFA</i>	(5) <i>Revenue</i>	(6) <i>Expenditure</i>	(7) <i>Growth</i>
Shadow economy, s_{it} (% GDP, DGE)	-0.264* (0.151)	-13.585 (21.428)	-0.207** (0.101)	13.445 (21.408)	0.158 (0.122)	-0.141 (0.121)	0.234*** (0.081)
Output gap (HP filter, $\lambda = 6.25$)	-37.548*** (13.519)	-2030.437 (1911.999)	6.462 (7.416)	1984.303 (1910.668)	6.338 (7.382)	10.203** (4.904)	
Trade openness (% GDP)	-0.030* (0.017)	2.146 (2.448)	-0.038*** (0.010)	-2.140 (2.449)	0.059*** (0.016)	0.019 (0.016)	0.042*** (0.011)
Log GDP per capita (current USD)	1.475 (1.930)	1401.197 (1332.501)	-2.894*** (0.881)	-1396.716 (1332.994)	2.243** (1.113)	-0.968 (1.317)	2.672*** (0.752)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2416	2337	2731	2337	2754	2742	2870
Countries	112.000	112.000	112.000	112.000	112.000	112.000	112.000
Within R-sq	0.093	0.026	0.150	0.026	0.158	0.115	0.220

Notes: Standard errors in parentheses. Panel FE with year dummies and clustered SE. All dependent variables in % of GDP except Growth (%). *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

Table 15 ties the mechanism evidence directly to the paper's main identification design by replacing the dependent variable in the GFC exposure regression with channel outcomes. The primary-balance coefficient remains positive and significant: a one-standard-deviation higher pre-GFC shadow economy predicts a 0.768 percentage point larger post-2008 primary-balance adjustment. Government revenue also rises by 0.968 percentage points at the 10% level, while tax revenue is positive but imprecise in the smaller tax-revenue sample. By contrast, government expenditure, GDP growth, the interest-growth differential, and the change in debt do not show statistically sharp post-GFC differentials. The mechanism pattern therefore supports a constrained-adjustment interpretation: the

crisis response is visible in the primary balance, with some evidence of revenue effort, but not as a clean spending-compression, growth, snowball, or debt-stock effect.

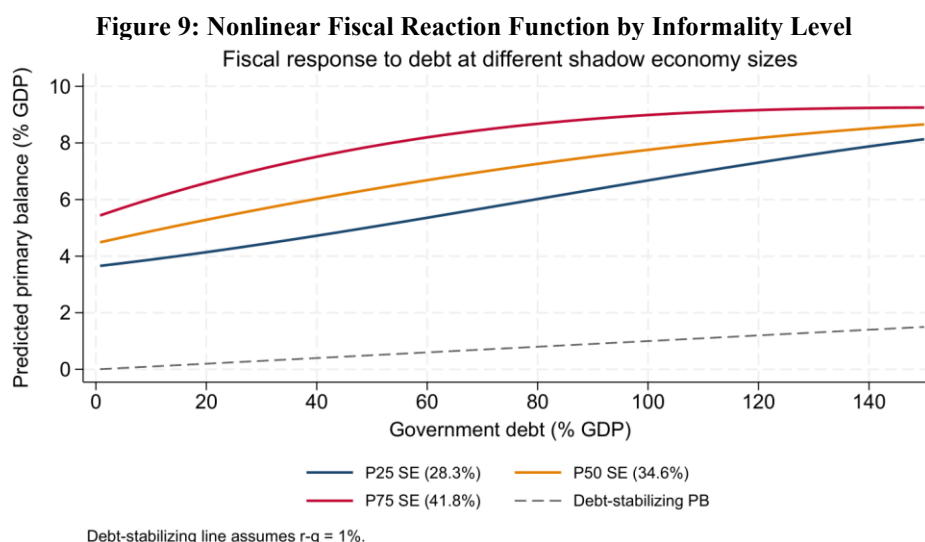
Table 15. GFC Exposure Design: Mechanism Channels

	(1) <i>Primary bal- ance</i>	(2) <i>Govt. reve- nue</i>	(3) <i>Tax reve- nue</i>	(4) <i>Govt. expendi- ture</i>	(5) <i>GDP growth</i>	(6) <i>Interest-growth gap</i>	(7) <i>Debt change</i>
Pre-GFC s (std.) $\times$ $Post_t$	0.768** (0.302)	0.968* (0.513)	2.378 (1.675)	0.403 (0.488)	0.282 (0.285)	0.902 (1.028)	-0.569 (0.357)
Observations	2395	2414	1506	2403	2417	2337	2417
Countries	112.000	112.000	95.000	112.000	112.000	112.000	112.000
Within R-sq	0.142	0.131	0.055	0.116	0.304	0.157	0.241

Notes: Standard errors in parentheses. Each column uses the same predetermined GFC exposure: mean pre-2008 shadow economy, standardized, interacted with post-2008. All columns include country fixed effects, year fixed effects, lagged debt, the output gap, and trade openness. The expenditure gap is omitted from this mechanism table because it is mechanically tied to channel outcomes. Standard errors are clustered by country; $r - g$ and debt change are winsorized at the 1st and 99th percentiles. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

Individual country trajectories illustrate these aggregate patterns but do not drive them. Brazil's experience under the Fiscal Responsibility Law of 2000 is suggestive of a formalization dividend, while Nigeria exemplifies the fiscal fragility associated with persistently high informality and narrow tax capacity. India's post-GST (goods and services tax) trajectory is more mixed, underscoring that the fiscal payoff from formalization depends on how much administrative capacity and tax compliance improve alongside reform.

The fiscal-space analysis is best read as a supplementary policy illustration rather than as a headline result. Figure 9 plots the estimated nonlinear fiscal reaction function at the 25th, 50th, and 75th percentiles of shadow economy size, while Online Appendix Figure A6 maps the implied debt-limit schedule. In the regenerated outputs, finite debt limits are obtained for some low- and medium-informality values, while other grid points do not produce a finite intersection with the debt-stabilizing line over the search range. We therefore use this exercise only to illustrate that informality can reshape nonlinear fiscal capacity; we do not treat the resulting debt-limit gradient as a precisely estimated quantitative object, and it should remain subordinate to the paper's stronger dynamic, timing-based, and mechanism evidence.



Notes: Estimated cubic FRF at the 25th (low), 50th (medium), and 75th (high) percentiles of shadow economy size. Dashed line: debt-stabilizing primary balance assuming $r - g = 1\%$.

The threshold panel model identifies a critical shadow economy level of approximately 27 percent of GDP, with a bootstrap 95 percent confidence interval of [18.6, 48.6]. In the preferred specification (Column 2 of Table 16), the fiscal response to debt in the low-informality regime is 0.005 and in the high-informality regime 0.018 ($p < 0.10$). With additional controls in Column (4), the low-regime coefficient rises to 0.016 ($p < 0.05$) and the high-regime coefficient to 0.018 ($p < 0.01$). The threshold model therefore identifies regime heterogeneity, but not the simple monotone pattern in which higher informality mechanically weakens the debt response. The estimated threshold (27 percent) falls near the 25th percentile of the shadow-economy distribution (about 28 percent) and well below the sample median of about 35 percent, so the regime break occurs at relatively low informality and most of the sample lies in the high-informality regime.

Table 16. Threshold Panel Regression

	(1)	(2)	(3)	(4)
Debt response: low-informality regime	-0.0722 (0.0654)	0.0053 (0.0138)	0.0157 (0.0166)	0.0164** (0.0064)
Debt response: high-informality regime	-0.0192 (0.0249)	0.0175* (0.0091)	0.0158* (0.0092)	0.0177*** (0.0037)
Shadow economy: low-informality regime			0.3676** (0.1423)	
Shadow economy: high-informality regime			0.4332*** (0.1235)	
Shadow economy, s_{it} (% GDP, DGE)	-1.4373 (1.2361)	0.4502*** (0.1235)		0.1391*** (0.0327)
Primary balance, $pb_{i,t-1}$ (% GDP)				0.5650*** (0.0411)
Output gap (HP filter, $\lambda = 6.25$)	15.5067 (12.8096)	2.4852 (10.8743)	2.6431 (10.9344)	4.8268 (6.4921)
Government expenditure gap (HP filter)	-56.0948* (29.3363)	-19.1562*** (2.6472)	-19.1339*** (2.6503)	-19.8838*** (2.7625)
Trade openness (% GDP)		0.0497*** (0.0129)	0.0484*** (0.0128)	0.0216*** (0.0070)
Log GDP per capita (current USD)		1.2019* (0.6855)	1.1687* (0.6941)	
_Cons	50.4239 (43.9631)	-29.3006*** (9.7446)	-28.0920*** (9.8931)	-7.2840*** (1.3753)
Observations	2780	2394	2394	2378
Countries	112.000	112.000	112.000	112.000
Within R-sq	0.1935	0.1563	0.1584	0.4708

Notes: Standard errors in parentheses. Threshold: 27 % of GDP. Low regime: SE at or below threshold; High regime: SE above threshold. Panel FE with clustered SE. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

The local projection impulse responses in Figure 10 show that a one-percentage-point increase in the shadow economy is followed by a negative debt response, reaching its largest magnitude of roughly 10 percentage points of GDP around horizons 2–3 before gradually reverting toward zero. Consistent with the nonlinear amplification mechanisms described in Section 3, the state-dependent local projections in Figure 11 indicate that fiscal responses differ markedly across regimes, with stronger adjustments in high-informality countries.

Figure 10: Local Projection Impulse Responses to Informality Shocks

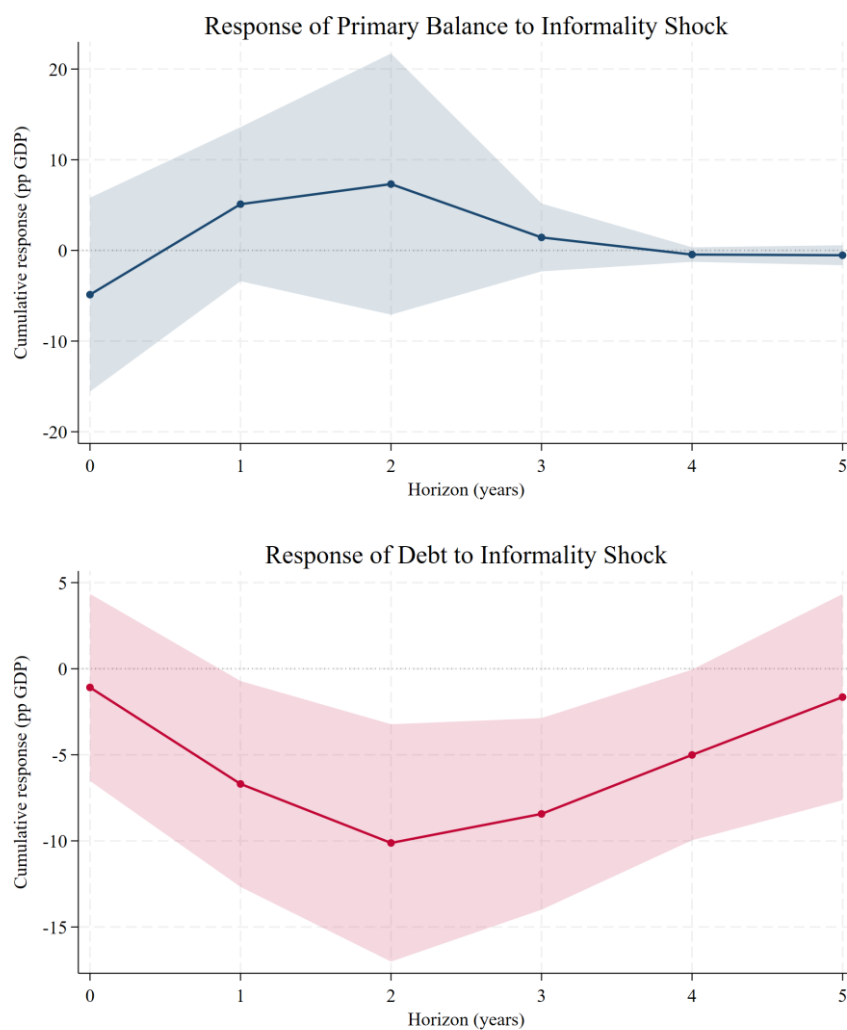
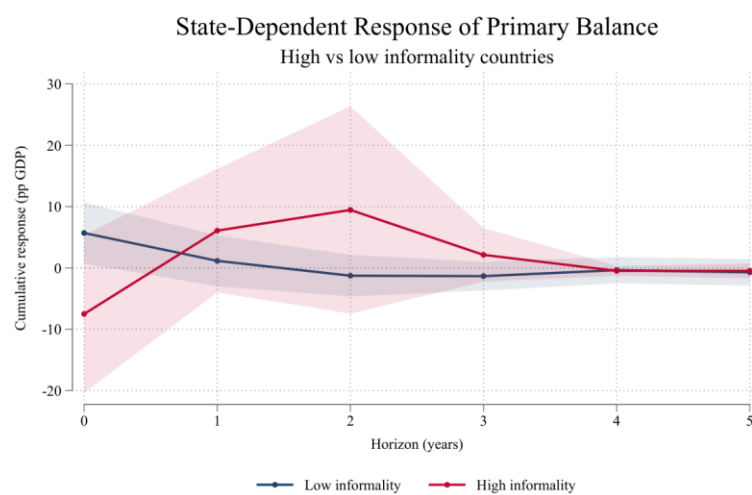


Figure 11: State-Dependent Impulse Responses: High vs. Low Informality



7. Robustness and Extensions

The core finding of the paper is that informality matters for fiscal vulnerability in developing economies, but the strength of the debt-interaction term varies materially across specifications. Having presented the crisis-timing design and its placebo, pre-trend, leave-out, and pre-crisis-control checks in Section 6 and the Online Appendix, this section turns to alternative measures, estimation strategies, and sample definitions. The broad association between informality and weaker fiscal outcomes survives these checks more clearly than a uniformly negative and significant interaction coefficient does. IV, GMM, and alternative-specification results are therefore interpreted as sensitivity checks around the shock-timing and mechanism evidence rather than as substitutes for it.

Table 17 reports a high-standard robustness battery for the central GFC exposure coefficient. The positive post-2008 differential survives country-specific linear trends, region-year fixed effects, winsorization of the primary-balance outcome, exclusion of debt observations above 150 percent of GDP, restriction to the 2003–2016 event window, and exclusion of the immediate 2008–2009 crisis years. The coefficient ranges from 0.615 to 0.984 percentage points of GDP and remains statistically significant in all seven columns. Table 18 then asks whether the result is fragile to inference or influence. A country-level randomization exercise that reassigns pre-GFC informality across the 112 estimating countries yields a two-sided randomization p-value of 0.022. A full leave-one-country-out exercise produces coefficients between 0.645 and 0.851, with all 112 estimates positive and significant at the 10 percent level. These diagnostics do not turn the design into a randomized experiment, but they make the main shock-timing coefficient much harder to attribute to one country, one specification, or conventional clustered-inference fragility.

Table 17. High-Standard Robustness: GFC Exposure Design

	(1) <i>Baseline</i>	(2) <i>Country trends</i>	(3) <i>Region-year FE</i>	(4) <i>Winsorized PB</i>	(5) <i>Debt<150</i>	(6) <i>2003-16 window</i>	(7) <i>Excl. 2008-09</i>
Pre-GFC s (std.) $\times Post_t$	0.758** (0.297)	0.948** (0.418)	0.615** (0.260)	0.680** (0.269)	0.794*** (0.293)	0.984*** (0.350)	0.892*** (0.336)
Debt, $d_{i,t-1}$ (% GDP)	0.013* (0.007)	0.017* (0.010)	0.013 (0.008)	0.013* (0.007)	0.025*** (0.008)	0.031** (0.013)	0.012* (0.007)
Observations	2395	2395	2395	2395	2347	1482	2179
Countries	112.000	112.000	112.000	112.000	112.000	111.000	112.000
Within R-sq	0.219	0.327	0.304	0.238	0.219	0.282	0.220

Notes: Standard errors in parentheses. Dependent variable is the primary balance except Column (4), which uses winsorized primary balance. All columns include country fixed effects and the standard GFC controls unless otherwise indicated. Standard errors are clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table 18. High-Standard Inference and Influence Diagnostics

<i>Diagnostic</i>	<i>Value</i>
Observed coefficient	0.758
Clustered standard error	0.297
Country-clustered p-value	0.012
Randomization p-value	0.022
Permutation replications	500
Permutation mean coefficient	-0.015
Permutation s.d.	0.326
Leave-one-country-out minimum	0.645 (KWT)
Leave-one-country-out p10	0.728
Leave-one-country-out median	0.758
Leave-one-country-out p90	0.784
Leave-one-country-out maximum	0.851 (QAT)
Positive leave-one-out estimates	100.0%
Leave-one-out estimates significant at 10%	100.0%
Leave-one-out 95% CIs above zero	100.0%

Notes: Randomization inference reassigns the predetermined country-level pre-GFC informality exposure across countries, preserving the panel structure and re-estimating the baseline GFC specification 500 times. Leave-one-country-out diagnostics re-estimate the baseline specification after removing each estimating country in turn.

Table 19. Robustness: ILO Informal Employment Measure

	(1) <i>Shadow economy</i>	(2) <i>ILO informal</i>	(3) <i>Both</i>	(4) <i>ILO + controls</i>
Debt, $d_{i,t-1}$ (% GDP)	0.145*** (0.020)	0.115*** (0.031)	0.162*** (0.030)	0.106*** (0.027)
Shadow economy, s_{it} (% GDP, DGE)	0.562*** (0.123)		0.409*** (0.122)	
$s_{it} \times d_{i,t-1}$	-0.003*** (0.001)		-0.002*** (0.001)	
Informal employment (% of employment, ILO)		0.148*** (0.046)	0.086* (0.046)	0.148*** (0.050)
Informal employment $\times d_{i,t-1}$		-0.001*** (0.000)	-0.001 (0.001)	-0.001*** (0.000)
Output gap (HP filter, $\lambda = 6.25$)	18.939*** (5.868)	23.189*** (6.170)	21.760*** (5.935)	24.338*** (5.953)
Government expenditure gap (HP filter)	-20.350*** (3.819)	-19.980*** (3.821)	-20.178*** (3.766)	-20.964*** (3.996)
Trade openness (% GDP)	0.045** (0.019)	0.061*** (0.021)	0.047** (0.021)	0.063*** (0.021)
Log GDP per capita (current USD)				-0.647 (0.477)
WGI: Regulatory Quality				0.932 (0.820)
Observations	535	535	535	530
Countries	83.000	83.000	83.000	83.000
Within R-sq	0.430	0.411	0.450	0.432

Notes: Standard errors in parentheses. Same sample (with ILO data available). Panel FE, clustered SE. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table 19 replaces the Elgin et al. shadow-economy measure with ILO informal employment shares, a conceptually distinct indicator that captures labour-market informality directly rather than through model-based estimation. Despite the much sparser coverage of the ILO data, the interaction between informal employment and debt is negative and significant when the ILO measure is entered on its own and in the richest ILO specifica-

tion. When both measures are included simultaneously in Column (3), the shadow-economy interaction remains negative and significant, while the ILO interaction becomes imprecise. Online Appendix Table A3 extends this measurement check to the MIMIC shadow-economy estimate and to the DGE/MIMIC average. The DGE and MIMIC measures are very highly correlated, but the pooled debt-interaction coefficient remains small under the model-based alternatives, whereas the ILO interaction is negative in the smaller labour-informality sample. This reinforces the paper's main measurement lesson: the average pooled interaction is not the most stable object, while the crisis-timing, channel, and state-dependent evidence carry more of the substantive interpretation.

Table 20 addresses the main identification concern: that informality is endogenous to fiscal outcomes, either because weak fiscal institutions simultaneously produce large deficits and large informal sectors, or because fiscal pressure drives activity underground. Column (1) instruments the shadow economy with lagged regulatory quality from the WGI and the agricultural employment share, and the Kleibergen-Paap F-statistic exceeds 10. Column (2) instead uses deeper lags of the shadow economy and the interaction term as instruments. In both IV specifications, however, the interaction coefficient is economically tiny and statistically weak once rounded. Columns (3) and (4) report system GMM estimates with and without instrument collapse. These coefficients are again close to zero, and the diagnostics are mixed: the uncollapsed specification produces a Hansen p-value of 1.000, while the collapsed specification yields Hansen and AR(2) p-values around 0.04. These exercises are therefore best interpreted as sensitivity checks showing that endogeneity-robust designs do not sharpen the interaction result.

Table 20. Robustness: IV and GMM Estimation

	(1) <i>IV-FE (ext)</i>	(2) <i>IV-FE (lags)</i>	(3) <i>Sys-GMM</i>	(4) <i>Sys-GMM (col)</i>
Primary balance, $pb_{i,t-1}$ (% GDP)			0.722*** (0.056)	0.661*** (0.068)
Debt, $d_{i,t-1}$ (% GDP)	0.007 (0.077)	0.001 (0.032)	-0.006 (0.013)	0.002 (0.058)
Shadow economy, s_{it} (% GDP, DGE)	0.429*** (0.152)	0.319*** (0.094)	-0.028 (0.032)	-0.018 (0.154)
$s_{it} \times d_{i,t-1}$	0.000 (0.002)	0.000 (0.001)	0.000 (0.000)	0.000 (0.001)
Observations	1922	2283	2378	2350
KP F-stat	11.915	3402.261		
Hansen p-value			1.000	0.040
AR(2) p-value			0.039	0.038
Hansen J (IV) / N instruments (GMM)	1.746	4.545	436.000	22.000
Countries	112.000	112.000	112.000	112.000

Notes: Standard errors in parentheses. Col (1)-(2): IV-FE with external instruments. Col (3)-(4): Two-step System GMM, Windmeijer SE. Diagnostic row reports Hansen J in IV columns and instrument counts in GMM columns. Instruments: t-2 to t-4 lags of endogenous variables. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

The results are also not driven by a single region or income group, but the interaction evidence becomes much more uneven in subsamples. Table A6 in the Online Appendix shows that the direct effect of informality on the primary balance is positive in several regions, yet the debt interaction is mostly small and imprecise. Table A7 tells a similar story: the direct effect is strongest in middle-income groups, while the debt interaction is only weakly negative in the upper-middle-income subsample. Subsample evidence therefore supports heterogeneity in the fiscal role of informality, but not a uniformly estimated debt-response gradient.

The temporal stability of the result is tested by splitting the sample at 2008. Table A9 in the Online Appendix shows that the post-2008 coefficients do change, but the direction is specification-dependent: the centred interaction specification remains near zero, whereas the parsimonious interaction shift is positive and statistically significant. The resource-subsample results are equally mixed, with the non-resource sample showing a small negative interaction and the resource-rich sample a small positive one. These tables support the existence of heterogeneity across periods and country types, but they do not deliver a single monotone post-GFC pattern.

Table A8 in the Online Appendix presents results for seven alternative specifications designed to probe the sensitivity of the baseline to specific modelling choices: winsorization, lag structures, year fixed effects, country trends, a balanced panel, and exclusion of high-debt outliers. Here too the interaction terms cluster close to zero, with signs that move modestly across specifications. What is more stable across these alternatives is the positive direct coefficient on the shadow economy in richer specifications and the negative expenditure-gap effect. The main lesson from the alternative specifications is therefore not that the pooled interaction is invariant, but that the broader fiscal association of informality survives substantial perturbations of the baseline design.

Three further exercises sharpen the crisis-timing design and extend the rule-adoption scope check (the financing-constraint test that anchors the constrained-adjustment reading is now reported in the main text, Table 9). First, Table 21 adds continuous pre-crisis commodity exposure – the net barter terms of trade and the fuel-plus-ores export share – interacted with Post, restricts the sample to non-resource economies, and trims the most

commodity-dependent quartile, since the post-2008 commodity bust is the leading alternative explanation. The informality differential remains positive and statistically significant throughout (0.44–0.70), so it is not a repackaged commodity-cycle effect. Second, Table 22 decomposes the treated–control differential into a linear pre-2008 trend and a post-2008 level break and reports the break net of any pre-trend, Table 23 re-times the comparison to a 2005–2007 reference window, and Rambachan and Roth (2023) honest difference-in-differences bounds gauge how large a violation of parallel trends would overturn the result – together addressing the limited power of the joint pre-trend test. The post-2008 break survives netting out a differential linear pre-trend (which is itself small and insignificant), and the event study referenced to 2005–2007 shows insignificant pre-period coefficients. Finally, Table 24 re-estimates the fiscal-rule adoption scope check with the heterogeneity-robust Callaway and Sant’Anna (2021) estimator using never treated controls, separately for high- and low-informality adopters, confirming that the weak adoption differential is not an artifact of two-way fixed-effects weighting under staggered adoption timing. The heterogeneity-robust adoption effect is in fact no larger for high-informality adopters (and if anything, smaller), reinforcing that the informality mechanism is activated by large common stress rather than by routine institutional reform.

Table 21. GFC Design: Commodity / Resource Confound

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>Baseline</i>	<i>+TOT</i>	<i>+Comm. exp.</i>	<i>Both</i>	<i>Non-resource</i>	<i>Trim top comm.</i>
Pre-crisis s (std.) $\times Post_t$	0.758** (0.297)	0.739** (0.294)	0.671** (0.262)	0.698*** (0.262)	0.443* (0.236)	0.511** (0.228)
Pre-crisis terms of trade (std.) $\times Post_t$		0.750** (0.338)		0.552* (0.304)		
Pre-crisis commodity-export share (std.) $\times Post_t$			-0.551 (0.451)	-0.395 (0.449)		
Debt, $d_{i,t-1}$ (% GDP)	0.013* (0.007)	0.018** (0.008)	0.014* (0.008)	0.020** (0.008)	0.013 (0.009)	0.030*** (0.007)
Observations	2395	2368	2326	2299	1858	1706
Countries	112.000	111.000	108.000	107.000	89.000	82.000
Within R-sq	0.219	0.225	0.221	0.225	0.257	0.280

Notes: Standard errors in parentheses. Dependent variable: primary balance (% of GDP). Pre-crisis exposures are 1990–2007 means, standardised, interacted with post-2008. Terms of trade = net barter ToT index; commodity export share = fuel + ores/metals (% merch. exports). Col (5) drops resource-rich economies; col (6) drops the top pre-crisis commodity-export quartile. All columns include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

Table 22. GFC Event Study: Linear Pre-Trend vs. Post 2008 Break

	(1) <i>Break only</i>	(2) <i>+Pre-trend</i>	(3) <i>Excl. 2008-09</i>	(4) <i>2003-16 window</i>
High informality $\times$ pre-2008 linear trend		-0.219 (0.163)	-0.208 (0.158)	0.353 (0.231)
High informality $\times$ $Post_t$ (level break)	1.476** (0.587)	2.842** (1.198)	2.996** (1.282)	0.935 (1.155)
Debt, $d_{i,t-1}$ (% GDP)	0.014* (0.007)	0.015* (0.008)	0.014* (0.007)	0.036** (0.014)
Observations	2395	2395	2179	1482
Pre-trend slope p-value		0.183	0.191	0.129
Countries	112.000	112.000	112.000	111.000
Within R-sq	0.218	0.222	0.223	0.282

Notes: Standard errors in parentheses. Dependent variable: primary balance (% of GDP). Pre-trend slope is the high-informality differential trend over pre-2008 years. The post-2008 level break is identified net of any linear pre-trend. All columns include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

Table 23. GFC Event Study: 2005-2007 Reference Window

	<i>Primary balance</i>
High informality $\times t = -5$	-0.903 (0.792)
High informality $\times t = -4$	-1.027 (0.718)
High informality $\times t = 0$	-0.193 (0.850)
High informality $\times t = 1$	1.548 (0.967)
High informality $\times t = 2$	1.638* (0.927)
High informality $\times t = 3$	1.344 (0.905)
High informality $\times t = 4$	1.572 (1.034)
High informality $\times t = 5$	1.291 (0.950)
Observations	1482
Joint pre-trend p-value	0.363
Countries	111.000
Within R-sq	0.288

Notes: Standard errors in parentheses. Omitted (reference) category is event-time -3 to -1 (2005-2007). All specifications include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

Table 24. Fiscal-Rule Adoption: Heterogeneity-Robust (Callaway-Sant'Anna) DiD

<i>Comparison group</i>	<i>ATT (pp of GDP)</i>	<i>Std. Err.</i>	<i>Obs.</i>
All adopters	0.799	(0.784)	2124
High informality	-0.597	(1.176)	1590
Low informality	1.466**	(0.674)	1656

Notes: Callaway-Sant'Anna ATT with never-treated controls; doubly robust. Outcome: primary balance (% of GDP). *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively.

8. Limitations

The evidence should be read with five limitations in mind. These limitations do not overturn the paper’s central result, but they define the scope of the claim. The paper identifies a robust stress-conditioned association between predetermined informality and post-shock fiscal adjustment. It does not identify a universal structural law linking informality to fiscal policy in all countries and years.

First, the GFC exposure design is stronger than a pooled association but remains a quasi-experimental design. Pre-2008 informality is predetermined with respect to the post-2008 fiscal path, and the common timing of the Global Financial Crisis is external to individual developing economies. Still, countries with larger informal sectors may also differ in ways that are difficult to observe fully, including financial openness, commodity exposure, state capacity, exchange-rate regimes, and political constraints. Country effects, year effects, region-year effects, pre-crisis controls, placebo outcomes, randomization inference, and leave-one-country-out diagnostics reduce this concern, but they cannot make informal-sector exposure randomly assigned. The fiscal-rule adoption design provides a useful non-GFC timing check, yet it is even less exogenous because fiscal rules are policy choices and may be adopted precisely when governments anticipate fiscal pressure.

Second, informality is difficult to measure. The DGE shadow-economy estimates provide broad country-year coverage and are widely used, but they are model-based approximations rather than direct observations. MIMIC estimates are highly correlated with the DGE series, which is reassuring for broad cross-country patterns but does not remove common model-dependence. ILO informal-employment data measure a different concept and provide a valuable external check, but the coverage is much sparser and concentrated in a subset of countries and years. Measurement error is therefore likely, and it may affect the estimated interaction terms in different ways across pooled, event-study, and mechanism specifications.

Third, the fiscal mechanisms are reduced-form and partly constrained by data quality. The primary balance is the most stable margin in both the debt-dynamics decomposition and the GFC channel regressions, but aggregate fiscal data cannot fully separate tax-base broadening, tax enforcement, temporary revenue measures, arrears accumulation, expenditure compression, or accounting changes. Debt-dynamics components are also sensitive to inflation episodes, exchange-rate movements, debt restructurings, and stock-flow adjustments. For this reason, the mechanism evidence supports a constrained-adjustment

interpretation, but it does not identify a single microeconomic channel through which informality changes fiscal behaviour.

Fourth, the evidence is strongest for stress episodes and should not be generalized mechanically to tranquil periods. The post-GFC estimates show that informality becomes fiscally consequential when financing conditions tighten and governments face a common adverse shock. They do not imply that high-informality countries always adjust more, or that formalization automatically improves fiscal outcomes in the short run. The fiscal-rule adoption exercise reinforces this boundary: even with clean pre-trends, the informality differential around rule adoption is short-lived rather than persistent. The paper therefore speaks most directly to adjustment under stress, not to every institutional reform or every phase of the business cycle.

Fifth, the analysis is conducted at the country-year level and cannot substitute for country-specific institutional diagnosis. Informality differs across contexts: it may reflect low-productivity self-employment, regulatory avoidance by firms, weak enforcement capacity, political bargains, or exclusion from formal labour markets. The fiscal consequences of formalization also depend on administrative capacity, compliance costs, enforcement quality, and the design of social protection. The cross-country evidence shows that informality should enter fiscal-capacity assessments, but it does not deliver a one-size-fits-all reform package or a precise welfare ranking of formalization policies.

These caveats motivate a cautious interpretation of the results. The paper's strongest claim is not that informality has a stable average effect on the fiscal reaction coefficient. It is that informality conditions governments' room for manoeuvre when debt stress binds, and that this constraint is most visible in primary-balance adjustment after large shocks. Future work can build on this evidence by linking administrative tax data, firm-level informality, and country-specific fiscal institutions to the aggregate patterns documented here.

9. Conclusion

This paper has argued that informality is best understood as a constraint on fiscal adjustment capacity, especially when governments are forced to respond under stress. A large shadow economy lowers the formal tax base and raises the cost of durable revenue mobilization. Yet once financing conditions tighten, that same weakness can also produce sharper observed primary-balance correction. The central empirical lesson is therefore

not that informality improves fiscal discipline. It is that high-informality governments may have less room to smooth shocks.

Three results support that interpretation. First, the strongest evidence is shock-conditioned: countries entering the Global Financial Crisis with higher pre-crisis informality followed distinct post-2008 primary-balance paths, with no significant differential pre-trend before the shock (a parallel-trends test with limited power, but the break survives netting out a linear pre-trend). The result survives country trends, region-year shocks, alternative event windows, randomization inference, and full leave-one-country-out diagnostics. A separate fiscal-rule adoption event study provides a useful non-GFC timing check, but it yields only a short-lived adoption-year differential rather than a persistent post-event pattern. Second, time-varying and rolling-window estimates point to a deterioration in the informality–debt nexus around the same period, suggesting that the common shock revealed constraints muted in average pooled regressions. Third, the mechanism and regime exercises especially the debt-dynamics decomposition, GFC channel regressions, threshold estimates, and state-dependent local projections indicate that the primary balance is the key adjustment margin and that informality matters through states and episodes rather than through one invariant average slope.

These conclusions also clarify what the paper does not establish. The broader claim that informality uniformly flattens the fiscal response to debt in every specification receives mixed support: time-varying and alternative measure exercises point in that direction, while pooled FE, IV, and GMM interaction estimates are often small and imprecise. Nor do we interpret the positive post-2008 primary-balance differential in the crisis-timing exercise as evidence that informality strengthens fiscal capacity. Our reading is the opposite: higher-informality countries appear to face tighter financing constraints and therefore sharper adjustment once a common shock hits. Likewise, the nonlinear fiscal-space exercise shows that informality can reshape debt limits, but the implied schedule is model-sensitive and does not yield a clean monotone quantitative gradient across the full grid.

The policy implication is straightforward. Debt sustainability analyses routinely condition on revenue projections, growth assumptions, and fiscal rules, but they rarely treat informality as a separate structural determinant of fiscal capacity. The findings here suggest that doing so would give a more realistic assessment of fiscal vulnerability, particularly where informal activity remains large. The relevant lesson is not a single calibrated debt-limit gain from formalization. It is that formalization affects the state’s ability to

generate primary surpluses, absorb shocks, and preserve room for manoeuvre when debt is rising.

The limitations discussed above point to the next research frontier. Future work should connect aggregate fiscal behaviour to administrative tax records, firm-level informality, and country-specific institutions so that the constrained-adjustment mechanism can be traced at a finer level. For policy, the message is already clear enough: informality should be treated as part of fiscal-capacity analysis, especially when governments face debt stress and the space for gradual adjustment has narrowed.

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Online Appendix

This appendix provides supplementary material for the main analysis. Table A4 lists all countries in the analysis sample with their regional classification and the number of years of available data. Table A5 reports pairwise correlations among the main variables.

Replication note. The replication package contains a master workflow that rebuilds the analysis sample, integrates the auxiliary fiscal-rules and updated ILO inputs used in the final paper, regenerates the paper-facing tables and figures, and then compiles the manuscript. A lighter refresh driver reproduces the paper outputs without rerunning the full legacy workflow. The appendix materials below correspond to that cleaned replication path.

Data audit and measurement validation. Tables A1–A3 document the data coverage behind the main sample. The main fiscal variables are close to complete in the 3,333 country-year sample, while MIMIC shadow-economy estimates cover 91.4% and the ILO informal-employment measure covers only 18.2%. The DGE and MIMIC shadow economy measures are highly correlated (0.954 in country-year data and 0.983 in country averages; see Table A2), while the correlation with ILO informal employment is lower, as expected because employment informality and shadow output are related but distinct concepts. Table A3 shows that the pooled debt-interaction result remains measure-sensitive: DGE, MIMIC, and the DGE/MIMIC average produce small interaction terms, while the ILO interaction is negative and significant in the smaller ILO sample.

Table A1: Final-Sample Data Coverage

<i>Variable</i>	<i>Non-missing obs.</i>	<i>Countries</i>	<i>Years</i>	<i>Coverage (%)</i>
Primary balance	3299	122	1990-2020	99.0
Government debt	3037	122	1990-2020	91.1
Government revenue	3323	122	1990-2020	99.7
Government expenditure	3311	122	1990-2020	99.3
Shadow economy, DGE	3333	122	1990-2020	100.0
Shadow economy, MIMIC	3046	118	1993-2020	91.4
Informal employment, ILO	605	94	1997-2020	18.2
Informal employment, ILO 2025 update	604	93	1997-2020	18.1
GDP growth	3327	122	1990-2020	99.8
Inflation	3291	122	1990-2020	98.7
Trade openness	2873	112	1990-2020	86.2
Output gap	3212	122	1990-2019	96.4
Expenditure gap	3311	122	1990-2020	99.3
WGI average	2616	122	1996-2020	78.5
Fiscal-rule indicator	3333	122	1990-2020	100.0

Table A2: Informality Measurement Validation

<i>Comparison</i>	<i>Level</i>	<i>N</i>	<i>Countries</i>	<i>Correlation</i>
DGE vs. MIMIC shadow economy	Country-year	3046	118	0.954
DGE vs. MIMIC shadow economy	Country average	118	118	0.983
DGE shadow economy vs. ILO employment informality	Country-year	605	94	0.338
DGE shadow economy vs. ILO employment informality	Country average	94	94	0.332
MIMIC shadow economy vs. ILO employment informality	Country-year	599	91	0.366

Notes: Correlations compare available overlapping observations in the final analysis sample. ILO informal employment is a labour-market measure and is therefore not expected to match shadow output one-for-one.

Table A3: Robustness: Alternative Informality Measures

	<i>DGE</i>	<i>MIMIC</i>	<i>DGE/MIMIN avg</i>	<i>ILO employment</i>
Debt, $d_{i,t-1}$ (% GDP)	-0.005 (0.029)	-0.014 (0.031)	-0.012 (0.031)	0.115*** (0.031)
Shadow economy, s_{it} (% GDP, DGE)	0.301*** (0.082)			
Shadow economy, (% GDP), MIMIC		-0.013 (0.148)		
Shadow economy, (% GDP), DGE/ MIMIC avg.			0.316*** (0.092)	
Informal employment (% of employment, ILO)				0.148*** (0.046)
$s_{it} \times d_{i,t-1}$	0.000 (0.001)			
MIMIC $s_{it} \times d_{i,t-1}$		0.001 (0.001)		
Avg. $s_{it} \times d_{i,t-1}$			0.001 (0.001)	
Informal employment $\times d_{i,t-1}$				-0.001*** (0.000)
Observations	2395	2323	2395	535
Countries	112.000	111.000	112.000	83.000
Within R-sq	0.139	0.119	0.128	0.411

Notes: Standard errors in parentheses All regressions include country fixed effects and standard controls. Standard errors clustered by country. ILO column uses the smaller country-year sample with observed informal employment. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A4: Country List

<i>Country</i>	<i>Region</i>	<i>T_i</i>	<i>Country</i>	<i>Region</i>	<i>T_i</i>	<i>Country</i>	<i>Region</i>	<i>T_i</i>
BGD	EDA	31	BRA	LAC	21	BFA	SSA	31
BRN	EDA	31	BRB	LAC	27	BWA	SSA	23
BTN	EDA	31	CHL	LAC	31	CAF	SSA	31
CHN	EDA	31	COL	LAC	31	CIV	SSA	24
FJI	EDA	29	CRI	LAC	31	CMR	SSA	23
IDN	EDA	28	DOM	LAC	24	COD	SSA	25
IND	EDA	31	ECU	LAC	26	COG	SSA	31
KHM	EDA	25	GTM	LAC	26	COM	SSA	31
LAO	EDA	21	HND	LAC	31	CPV	SSA	27
LKA	EDA	31	JAM	LAC	31	ETH	SSA	31
MDV	EDA	31	LCA	LAC	31	GAB	SSA	31
MMR	EDA	23	MEX	LAC	31	GHA	SSA	31
MNG	EDA	30	NIC	LAC	24	GIN	SSA	31
MYS	EDA	31	PAN	LAC	27	GMB	SSA	21
NPL	EDA	21	PER	LAC	21	GNB	SSA	30
PHL	EDA	31	PRY	LAC	31	GNQ	SSA	31
THA	EDA	25	SLV	LAC	31	KEN	SSA	31
VNM	EDA	23	SUR	LAC	31	LBR	SSA	21
ALB	EDE	24	TTO	LAC	31	LSO	SSA	31
ARM	EDE	25	URY	LAC	22	MDG	SSA	31
AZE	EDE	27	VCT	LAC	31	MLI	SSA	21

<i>Country</i>	<i>Region</i>	<i>T_i</i>	<i>Country</i>	<i>Region</i>	<i>T_i</i>	<i>Country</i>	<i>Region</i>	<i>T_i</i>
BGR	EDE	23	VEN	LAC	31	MOZ	SSA	31
BIH	EDE	23	ARE	MENA	30	MRT	SSA	21
BLR	EDE	20	BHR	MENA	31	MUS	SSA	21
GEO	EDE	26	DZA	MENA	31	MWI	SSA	19
HRV	EDE	29	EGY	MENA	23	NAM	SSA	31
HUN	EDE	26	IRN	MENA	25	NER	SSA	26
KAZ	EDE	19	JOR	MENA	31	NGA	SSA	31
KGZ	EDE	26	KWT	MENA	29	RWA	SSA	29
MDA	EDE	26	LBN	MENA	31	SDN	SSA	31
MKD	EDE	24	MAR	MENA	31	SEN	SSA	27
POL	EDE	26	OMN	MENA	31	SLE	SSA	21
ROU	EDE	30	QAT	MENA	31	SWZ	SSA	31
RUS	EDE	24	SAU	MENA	30	TCD	SSA	26
TJK	EDE	23	SYR	MENA	21	TGO	SSA	31
TUR	EDE	21	TUN	MENA	30	TZA	SSA	30
UKR	EDE	26	YEM	MENA	31	UGA	SSA	24
ARG	LAC	29	PAK	Other	28	ZAF	SSA	21
BHS	LAC	31	AGO	SSA	25	ZMB	SSA	21
BLZ	LAC	25	BDI	SSA	29	ZWE	SSA	16
BOL	LAC	31	BEN	SSA	31			

Notes: T_i denotes the number of years with non-missing data for each country. Regional classification follows the IMF World Economic Outlook. EDA = Emerging and Developing Asia; EDE = Emerging and Developing Europe; LAC = Latin America and the Caribbean; MENA = Middle East and North Africa; SSA = Sub-Saharan Africa.

Table A5: Pairwise Correlation Matrix

	<i>Primary balance, pb_{it} (% GDP)</i>	<i>Debt, , d_{it} (% GDP)</i>	<i>Shadow economy, s_{it} (% GDP, DGE)</i>	<i>Real GDP growth (%)</i>	<i>Inflation, avg consumer prices (%)</i>	<i>Trade open- ness (% GDP)</i>	<i>Output gap (HP fil- ter, $\lambda =$ 6.25)</i>	<i>Interest rate – growth differen- tial</i>	<i>WGI: Regu- latory Quality</i>
Primary balance, pb_{it} (% GDP)	1.000	-0.141	0.065	0.185	-0.153	0.086	0.065	0.152	0.083
Debt, d_{it} (% GDP)	-0.141	1.000	0.017	-0.182	0.127	-0.073	-0.089	-0.125	-0.226
Shadow economy, s_{it} (% GDP, DGE)	0.065	0.017	1.000	0.034	-0.010	-0.090	-0.008	0.011	-0.307
Real GDP growth (%)	0.185	-0.182	0.034	1.000	-0.168	0.062	0.452	0.166	0.021
Inflation, avg consumer prices (%)	-0.153	0.127	-0.010	-0.168	1.000	-0.018	0.010	-1.000	-0.080
Trade openness (% GDP)	0.086	-0.073	-0.090	0.062	-0.018	1.000	0.019	0.017	0.329
Output gap (HP filter, $\lambda = 6.25$)	0.065	-0.089	-0.008	0.452	0.010	0.019	1.000	-0.011	0.033
Interest rate – growth differential	0.152	-0.125	0.011	0.166	-1.000	0.017	-0.011	1.000	0.080
WGI: Regulatory Quality	0.083	-0.226	-0.307	0.021	-0.080	0.329	0.033	0.080	1.000

Tables A6 and A7 report the fiscal reaction function estimated separately by region and by income group. These tables reinforce the paper’s broader message of heterogeneity: the direct coefficient on informality is often positive in richer specifications, while the interaction with debt is uneven across subsamples and should not be read as a single common slope.

Tables A8–A10 present additional robustness results. Table A8 reports seven alternative specifications (winsorized variables, alternative lags, year fixed effects, country-specific trends, balanced panel, and exclusion of high-debt outliers). Table A9 reports post-2008 interaction shifts within the full sample, and Table A10 distinguishes resource-rich from non-resource economies.

Table A6: Fiscal Reaction Function by Region

	<i>LAC</i>	<i>SSA</i>	<i>EDA</i>	<i>EDE</i>	<i>MENA</i>
Debt, $d_{i,t-1}$ (% GDP)	-0.008 (0.032)	0.005 (0.013)	-0.009 (0.035)	0.043** (0.017)	0.012 (0.056)
Shadow economy, s_{it} (% GDP, DGE)	0.440*** (0.119)	0.363*** (0.126)	0.112 (0.127)	0.124 (0.112)	1.080** (0.464)
$(s_{it} - \bar{s})(d_{i,t-1} - \bar{d})$	0.001 (0.002)	0.000 (0.002)	-0.003 (0.002)	-0.002 (0.002)	0.002 (0.003)
Observations	464	808	337	389	372
Countries	21.000	40.000	16.000	19.000	15.000
Within R-sq	0.338	0.182	0.184	0.275	0.109

Notes: Standard errors in parentheses. Panel FE with clustered SE. Each column: regional subsample. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A7: Fiscal Reaction Function by Income Group

	<i>Low income</i>	<i>Lower-middle</i>	<i>Upper-middle</i>
Debt, $d_{i,t-1}$ (% GDP)	-0.006 (0.011)	0.020 (0.015)	0.038** (0.016)
Shadow economy, s_{it} (% GDP, DGE)	0.149* (0.075)	0.514*** (0.169)	0.848*** (0.232)
$(s_{it} - \bar{s})(d_{i,t-1} - \bar{d})$	0.000 (0.001)	0.000 (0.001)	-0.003* (0.001)
Observations	663	851	629
Countries	57.000	80.000	58.000
Within R-sq	0.091	0.316	0.382

Notes: Standard errors in parentheses. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A8: Robustness: Alternative Specifications

	(1) <i>Winsorized</i>	(2) <i>SE lag1</i>	(3) <i>SE lag2</i>	(4) <i>Year FE</i>	(5) <i>Country trends</i>	(6) <i>Balanced</i>	(7) <i>Debt<150</i>
Debt, $d_{i,t-1}$ (% GDP)	-0.001 (0.028)	0.001 (0.029)	0.002 (0.032)	0.017 (0.029)	-0.003 (0.039)	-0.009 (0.053)	-0.001 (0.030)
Shadow economy, s_{it} (winsorized)	0.291*** (0.080)						
$s_{it}^w - d_{i,t-1}$	0.000 (0.001)						
Shadow economy, s_{it} (% GDP)		0.308*** (0.085)					
$s_{i,t-1} \times d_{i,t-1}$		0.000 (0.001)					
Shadow economy, $s_{i,t-2}$ (% GDP)			0.301*** (0.089)				
$s_{i,t-2} \times d_{i,t-1}$			0.000 (0.001)				
Shadow economy, s_{it} (% GDP, DGE)				0.088 (0.111)	1.637*** (0.364)	0.445*** (0.162)	0.294*** (0.084)
$s_{it} \times d_{i,t-1}$				-0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Observations	2395	2390	2372	2395	2395	1062	2347
Countries	112.000	112.000	112.000	112.000	112.000	46.000	112.000
Within R-sq	0.157	0.149	0.153	0.213	0.294	0.202	0.136

Notes: Standard errors in parentheses. All regressions include country FE and clustered SE. See text for details on each specification. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A9: Robustness: Pre- vs. Post – GFC

	<i>Full interactions</i>	<i>Parsimonious</i>
Debt, $d_{i,t-1}$ (% GDP)	-0.000 (0.008)	-0.022 (0.031)
Shadow economy, s_{it} (% GDP, DGE)	0.136 (0.089)	0.120 (0.099)
$(s_{it} - \bar{s})(d_{i,t-1} - \bar{d})$	0.001 (0.001)	
Post-GFC (2008+)	-5.473** (2.346)	-2.550*** (0.767)
$d_{i,t-1} \times Post_t$	0.023 (0.046)	
$s_{it} \times Post_t$	0.099 (0.065)	
$s_{it} \times d_{i,t-1} \times Post_t$	-0.000 (0.001)	0.001** (0.000)
$s_{it} \times d_{i,t-1}$		0.001 (0.001)
Observations	2395	2395
Countries	112.000	112.000
Within R-sq	0.164	0.158

Notes: Standard errors in parentheses Panel FE with clustered SE.
Post-GFC = 1 for years 2008 onwards. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

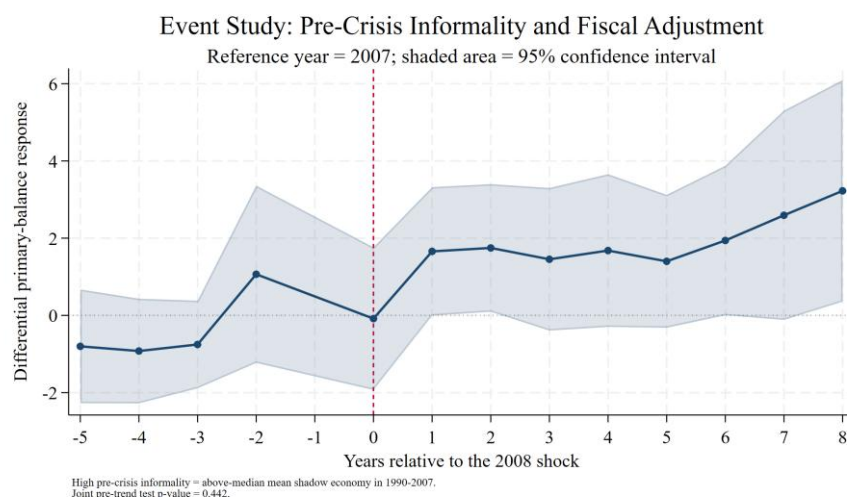
Table A10: Robustness: Resource-Rich vs. Non-Resource Economies

	<i>Non-resource</i>	<i>Resource-rich</i>
Debt, $d_{i,t-1}$ (% GDP)	0.017* (0.009)	-0.018 (0.017)
Shadow economy, s_{it} (% GDP, DGE)	0.254*** (0.060)	0.563** (0.240)
$(s_{it} - \bar{s})(d_{i,t-1} - \bar{d})$	-0.001 (0.001)	0.002 (0.002)
Observations	1858	537
Countries	89.000	23.000
Within R-sq	0.199	0.157

Notes: Standard errors in parentheses. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Figure A1 complements the crisis-exposure table reported in the main text by plotting the event-study coefficients for high- versus low-informality countries around the 2008 break. Table A11 reports the same coefficients in tabular form. The pre-2008 coefficients are statistically indistinguishable from zero jointly ($p = 0.442$), while the post-2008 coefficients turn positive and remain elevated for several years. This makes the timing-based exercise harder to explain as a continuation of a positive pre-existing trend.

Figure A1: Event Study: Pre-Crisis Informality and Post-2008 Fiscal Adjustment



Notes: Coefficients from an event-study regression of the primary balance on interactions between an above-median pre-2008 shadow-economy indicator and event-time dummies, with country and year fixed effects and standard controls. The omitted year is 2007. Shaded area: 95% confidence interval.

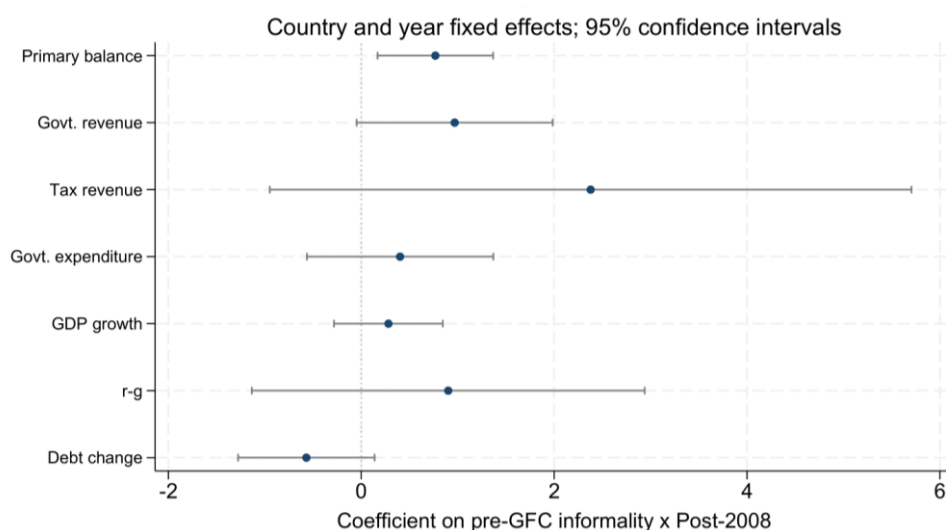
Table A11: GFC Event Study: Dynamic Exposure Coefficients

	<i>Primary balance</i>
High informality $\times t = -5$	-0.801 (0.743)
High informality $\times t = -4$	-0.923 (0.684)
High informality $\times t = -3$	-0.753 (0.573)
High informality $\times t = -2$	1.066 (1.158)
High informality $\times t = 0$	-0.083 (0.932)
High informality $\times t = 1$	1.658* (0.840)
High informality $\times t = 2$	1.747** (0.834)
High informality $\times t = 3$	1.453 (0.932)
High informality $\times t = 4$	1.679* (0.998)
High informality $\times t = 5$	1.401 (0.869)
High informality $\times t = 6$	1.940** (0.977)
High informality $\times t = 7$	2.593* (1.368)
High informality $\times t = 8$	3.226** (1.448)
Observations	1482
Joint pre-trend p-value	0.442
Countries	111.000
Within R-sq	0.289

Notes: Standard errors in parentheses Reference year is 2007. Each coefficient interacts event time with high pre-crisis informality. All specifications include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Figure A2 visualizes the channel estimates reported in Table 15. The confidence intervals make the same point as the table: the primary-balance margin is the clearest post-GFC response, while the remaining channels are less precisely isolated.

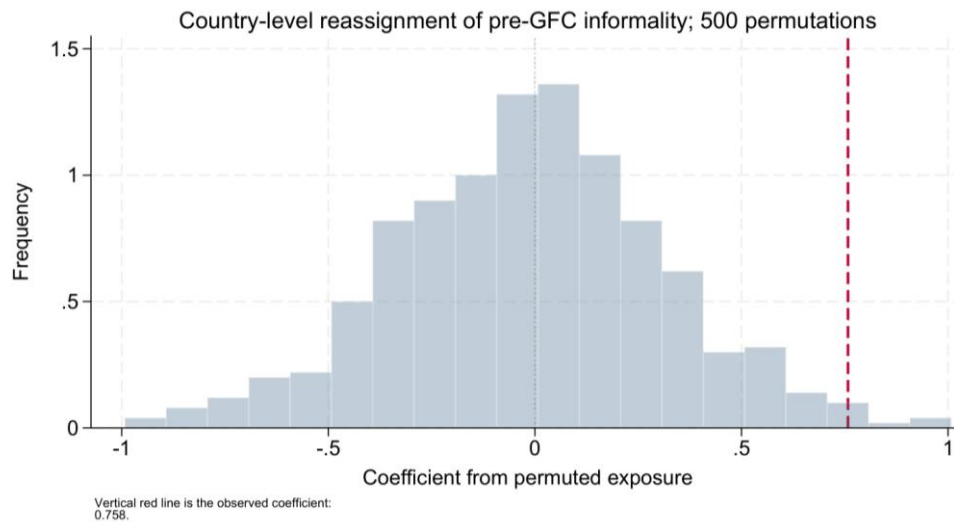
Figure A2: GFC Exposure Design: Mechanism Channels



Notes: Coefficients from channel-outcome regressions using the same pre-GFC informality exposure measure as the main GFC design. All specifications include country and year fixed effects, lagged debt, the output gap, and trade openness. Horizontal bars show 95% confidence intervals.

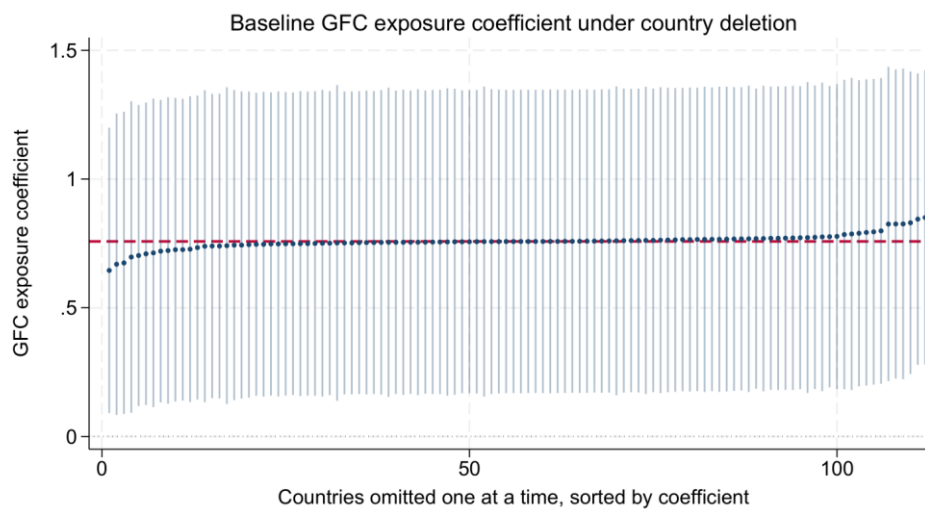
Figures A3 and A4 visualize the high-standard robustness diagnostics reported in Table 18. The randomization figure plots the distribution of placebo exposure coefficients from country-level reassignment of pre-GFC informality, while the leave-one-country-out figure plots the full deletion path for the baseline GFC coefficient.

Figure A3: Randomization Inference: GFC Exposure Coefficient



Notes: Distribution of coefficients from 500 country-level permutations of predetermined pre-GFC informality exposure. The vertical line marks the observed GFC exposure coefficient.

Figure A4: Leave-One-Country-Out Stability of the GFC Exposure Coefficient



Notes: Each point re-estimates the baseline GFC exposure specification after omitting one country. Countries are sorted by the resulting coefficient. Vertical intervals are 95% confidence intervals; the horizontal red line is the full-sample coefficient.

Tables A12–A17 report additional checks on the crisis-exposure design. The pre-crisis control interactions show that the informality coefficient remains positive after adding fiscal, macroeconomic, and institutional exposure controls, though precision falls in the most saturated specifications. The placebo-outcome table shows no significant effects on slow-moving institutional or capital-account outcomes. The placebo-year table shows that pre-2008 pseudo-breaks do not reproduce the positive post-GFC adjustment pattern. The

leave-out exercises show that the result is not driven by one large country and is present in most leave-one-region samples.

Table A12: GFC Design: Pre-Crisis Control Interactions

	<i>Fiscal</i>	<i>Macro/inst.</i>	<i>All + year FE</i>	<i>All + region-year FE</i>
Pre-crisis <i>s</i> (std.) $\times Post_t$	0.613* (0.312)	0.473* (0.266)	0.294 (0.282)	0.455 (0.325)
Pre-crisis <i>d</i> (std.) $\times Post_t$	0.188 (0.573)		-0.159 (0.627)	0.508 (0.705)
Pre-crisis <i>pb</i> (std.) $\times Post_t$	0.513 (1.196)		1.212 (0.823)	1.230* (0.694)
Pre-crisis <i>revenue</i> (std.) $\times Post_t$	-0.610* (0.367)		-0.366 (0.302)	-1.050*** (0.393)
Pre-crisis <i>current account</i> (std.) $\times Post_t$	0.100 (0.808)		-1.025** (0.441)	-0.859 (0.555)
Pre-crisis <i>GDP pc</i> (std.) $\times Post_t$		-0.535 (0.392)	-0.194 (0.398)	0.358 (0.562)
Pre-crisis <i>WGI</i> (std.) $\times Post_t$		0.148 (0.436)	0.047 (0.449)	0.224 (0.453)
Pre-crisis <i>KAOPEN</i> (std.) $\times Post_t$		-0.075 (0.269)	-0.141 (0.263)	0.073 (0.310)
Resource-rich $\times Post_t$		-1.511 (0.922)	-1.174 (0.782)	-0.408 (0.952)
Debt, $d_{i,t-1}$ (% GDP)	0.015* (0.009)	0.013* (0.008)	0.015* (0.009)	0.019* (0.010)
Observations	2375	2346	2326	2326
Countries	111.000	110.000	109.000	109.000
Within R-sq	0.223	0.232	0.242	0.349

Notes: Standard errors in parentheses. All exposure variables are measured before 2008 and interacted with Post-2008. Columns (1)-(3) include year fixed effects; column (4) includes region-year fixed effects. Standard errors clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A13: GFC Design: Alternative Post-Shock Windows

	<i>2008+</i>	<i>2009+</i>	<i>2010+</i>	<i>2008-12</i>	<i>2008-15</i>
Pre-crisis <i>s</i> (std.) $\times Post_t$	0.758** (0.297)				
Pre-crisis informality $\times Post$ (2009+)		0.892*** (0.335)			
Pre-crisis informality $\times Post$ (2010+)			0.856*** (0.325)		
Pre-crisis informality $\times 2009 - 2012$				-0.169 (0.389)	
Pre-crisis informality $\times 2008 - 2015$					-0.005 (0.323)
Debt, $d_{i,t-1}$ (% GDP)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.011 (0.007)	0.011 (0.007)
Observations	2395	2395	2395	2395	2395
Countries	112.000	112.000	112.000	112.000	112.000
Within R-sq	0.219	0.221	0.220	0.213	0.212

Notes: Standard errors in parentheses All columns include country and year fixed effects. Standard errors clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A14: GFC Design: Placebo Outcomes

	<i>WGI avg.</i>	<i>Polity2</i>	<i>KAOPEN</i>
Pre-crisis s (std.) $\times Post_t$	0.034 (0.024)	0.518 (0.330)	-0.060 (0.072)
Debt, $d_{i,t-1}$ (% GDP)	-0.001 (0.001)	0.000 (0.007)	-0.003* (0.001)
Observations	2070	1009	2352
Countries	112.000	48.000	110.000
Within R-sq	0.087	0.103	0.054

Notes: Standard errors in parentheses. Dependent variables are slow-moving institutional or capital-account measures. All columns include country and year fixed effects. Standard errors clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A15: GFC Design: Placebo Break Years before 2008

	<i>2001 placebo</i>	<i>2003 placebo</i>	<i>2005 placebo</i>
Pre-break informality (std.) $\times Placebo Post$	-1.464** (0.702)	-0.955** (0.470)	-0.550 (0.452)
Debt, $d_{i,t-1}$ (% GDP)	0.007 (0.009)	0.006 (0.008)	0.006 (0.008)
Observations	1091	1099	1099
Countries	105.000	107.000	107.000
Within R-sq	0.203	0.195	0.188

Notes: Standard errors in parentheses. Sample restricted to pre-2008 years. Placebo exposure is measured before each placebo break year. All columns include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A16: GFC Design: Leave-One-Region-Out Sensitivity

	<i>EDA</i>	<i>EDE</i>	<i>LAC</i>	<i>MENA</i>	<i>Other</i>	<i>SSA</i>
Pre-crisis s (std.) $\times Post_t$	0.907*** (0.328)	0.789** (0.323)	0.795** (0.388)	0.400 (0.269)	0.758** (0.298)	0.887*** (0.333)
Debt, $d_{i,t-1}$ (% GDP)	0.010 (0.007)	0.011 (0.007)	0.016** (0.007)	0.011 (0.008)	0.013* (0.007)	0.021 (0.013)
Observations	2058	2006	1931	2023	2370	1587
Countries	96.000	93.000	91.000	97.000	111.000	72.000
Within R-sq	0.239	0.232	0.213	0.234	0.219	0.212

Notes: Standard errors in parentheses. Column title reports the omitted region. All columns include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Table A17: GFC Design: Leave-One-Large-Country-Out Sensitivity

	<i>ARG</i>	<i>BRA</i>	<i>CHN</i>	<i>IND</i>	<i>IDN</i>	<i>MEX</i>	<i>NGA</i>	<i>RUS</i>	<i>TUR</i>	<i>ZAF</i>
Pre-crisis s (std.) $\times Post_t$	0.743** (0.304)	0.758** (0.297)	0.826*** (0.303)	0.799*** (0.300)	0.773** (0.305)	0.767** (0.299)	0.758** (0.297)	0.766** (0.297)	0.754** (0.298)	0.751** (0.300)
Debt, $d_{i,t-1}$ (% GDP)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)	0.013* (0.007)
Observations	2368	2376	2371	2367	2376	2372	2395	2373	2376	2376
Countries	111.000	111.000	111.000	111.000	111.000	111.000	112.000	111.000	111.000	111.000
Within R-sq	0.217	0.218	0.220	0.220	0.218	0.219	0.219	0.216	0.218	0.218

Notes: Standard errors in parentheses. Column title reports the omitted country. All columns include country and year fixed effects; SE clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

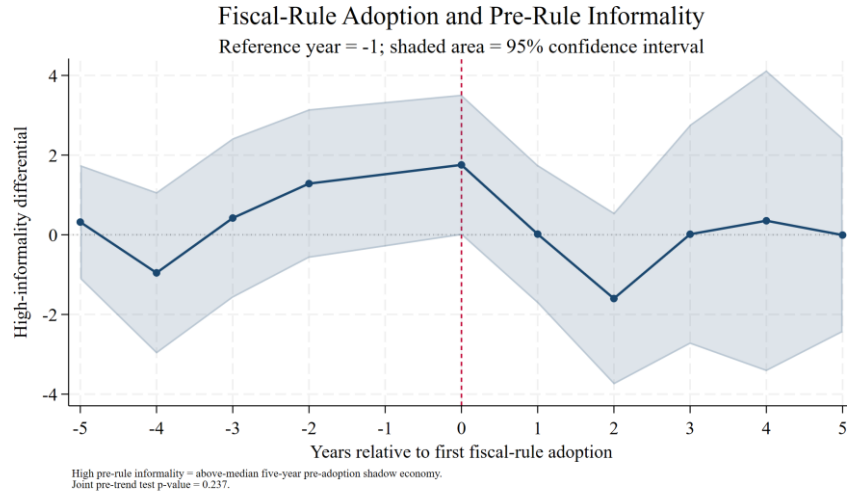
Figure A5 and Tables A18–A19 report a non-GFC policy-event check based on first fiscal-rule adoption. The design excludes countries already operating under a fiscal rule in their first observed year and requires at least three pre-adoption observations of informality. The event-study coefficients do not reject joint pre-trends ($p = 0.237$). The post-adoption pattern is much weaker than the GFC evidence: the adoption-year differential is positive at the 10% level, but subsequent coefficients are imprecise and do not form a persistent sequence.

Table A18: Fiscal-Rule Adoption Design

	<i>Binary exposure</i>	<i>Continuous exposure</i>	<i>Region-year FE</i>	<i>Pre-rule controls</i>
High pre-rule informality $\times Post_t$	0.452 (0.688)			
Pre-rule s (std.) $\times Post_t$		-0.047 (0.339)	-0.545 (0.385)	0.199 (0.262)
Post first fiscal-rule adoption	0.338 (0.646)	0.519 (0.556)	0.789 (0.584)	0.622 (0.582)
Pre-rule d (std.) $\times Post_t$				-0.004 (0.720)
Pre-rule pb (std.) $\times Post_t$				-1.414*** (0.411)
Pre-rule <i>revenue</i> (std.) $\times Post_t$				0.475 (0.384)
Pre-rule <i>WGI</i> (std.) $\times Post_t$				-0.828** (0.382)
Debt, $d_{i,t-1}$ (% GDP)	0.010 (0.007)	0.010 (0.007)	0.009 (0.008)	0.010 (0.007)
Observations	2266	2266	2266	2266
Countries	106.000	106.000	106.000	106.000
Within R-sq	0.221	0.221	0.311	0.226

Notes: Standard errors in parentheses. Treatment is first adoption of any fiscal rule. Informality exposure is the five-year pre-adoption mean. Columns (1), (2), and (4) include year FE; column (3) includes region-year FE. Standard errors clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Figure A5: Fiscal-Rule Adoption Event Study



Notes: Coefficients from an event-study regression of the primary balance on interactions between high pre-adoption informality and event-time dummies around first fiscal-rule adoption. The omitted year is $t = -1$. Shaded area: 95% confidence interval.

Table A19: Fiscal-Rule Adoption Event Study

	Primary balance
High informality $\times t = -5$	0.320 (0.722)
High informality $\times t = -4$	-0.956 (1.022)
High informality $\times t = -3$	0.421 (1.010)
High informality $\times t = -2$	1.286 (0.941)
High informality $\times t = 0$	1.755* (0.889)
High informality $\times t = 1$	0.017 (0.878)
High informality $\times t = 2$	-1.600 (1.088)
High informality $\times t = 3$	0.014 (1.389)
High informality $\times t = 4$	0.353 (1.905)
High informality $\times t = 5$	-0.006 (1.230)
Observations	2266
Joint pre-trend p-value	0.237
Countries	106.000
Within R-sq	0.225

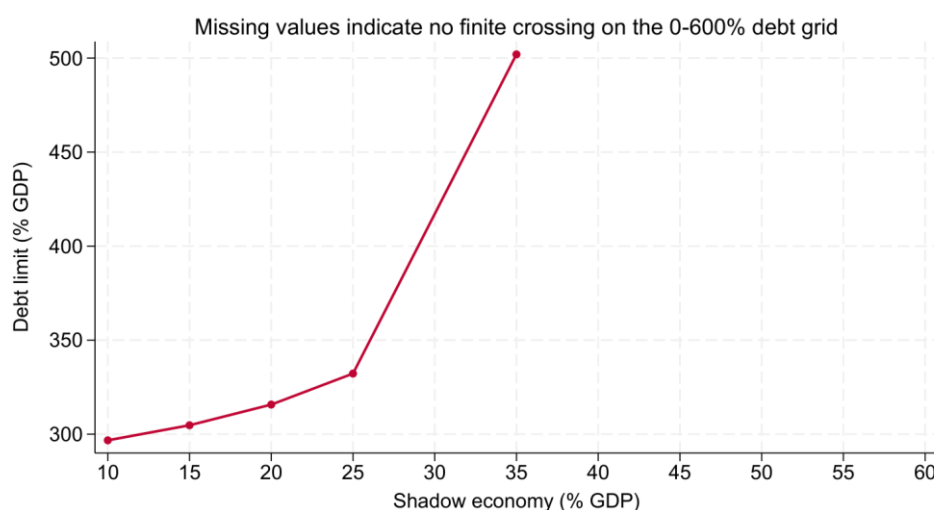
Notes: Standard errors in parentheses Reference year is $t=-1$. Specification includes event-time dummies, country FE, and year FE. Standard errors clustered by country. *, **, and *** represent statistical significance at levels of 10%, 5% and 1%, respectively

Figure A6 reports the debt-limit mapping associated with the nonlinear fiscal reaction function discussed in the main text. The schedule is irregular and finite only over part of

the informality grid, which is why the paper treats this exercise as supporting evidence rather than as a standalone quantitative calibration.

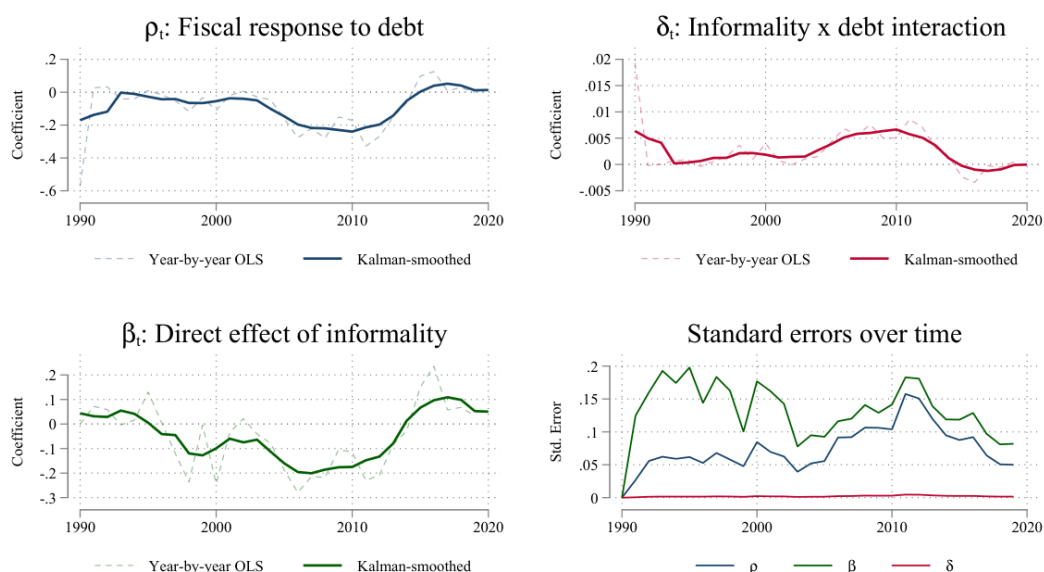
Figure A7 reports diagnostic plots for the two-step TVP estimation procedure. The top panels compare the year-by-year OLS estimates with the Kalman-smoothed paths for the fiscal response to debt (ρ_t) and the informality–debt interaction (δ_t). The bottom left panel shows the direct effect of informality (β_t), while the bottom-right panel displays the evolution of estimation precision over time. The smoothed estimates exhibit coherent trends that align with the cross-sectional evidence while filtering out year-to-year noise. Figure A8 compares the interaction coefficient across the three TVP approaches – year-by-year OLS, Kalman smoothing, and rolling windows – showing broadly similar deterioration around the post-2008 period, even if the precise path differs across methods.

Figure A6: Estimated Debt Limits by Informality Level



Notes: Debt limits implied by the nonlinear fiscal reaction function over the informality grid used in the fiscal-space exercise. Missing or truncated sections reflect cases in which no finite crossing with the debt-stabilizing line is obtained within the empirical search range.

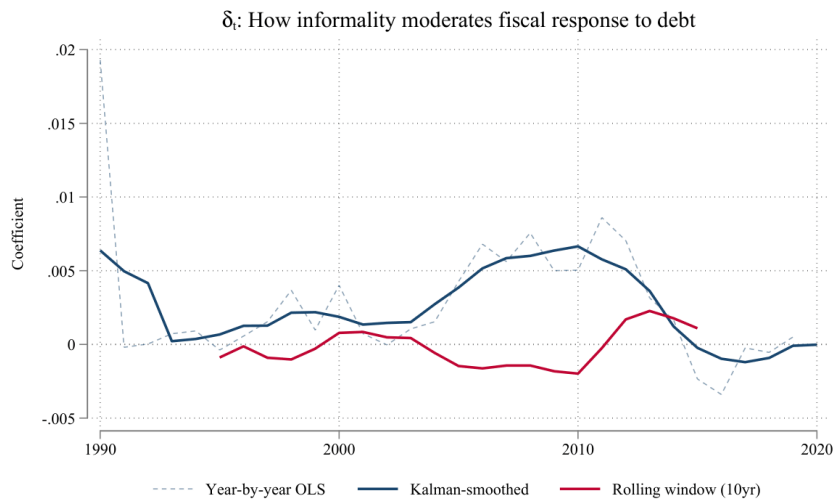
Figure A7: TVP Estimation Diagnostics



Comparison of year-by-year OLS estimates and Kalman-smoothed paths.
Bottom right: standard error evolution indicates estimation precision.

Notes: Comparison of year-by-year OLS (dashed) and Kalman-smoothed (solid) coefficient paths. Bottom-right: standard error evolution over time.

Figure A8: Comparison of TVP Approaches: Interaction Coefficient



Notes: Year-by-year OLS (thin dashed), Kalman-smoothed (solid), and 10-year rolling window (thick dashed). All three approaches point to a more adverse interaction around the post-2008 period, though they differ in smoothness and exact magnitude.