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RESEARCH ARTICLE

Fiscal Policy in an SNA-Compliant DSGE Model for Emerging Markets

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Abstract

Fiscal policy is often one of the economic Achilles heels of emerging markets. Therefore, adequately modeling it becomes crucial to understanding the effects of shocks impacting this class of economies. This paper seeks to make a new proposal on how to model an emerging market such as Brazil, with a particular emphasis on the fiscal side. To that end, we build a medium-scale open-economy DSGE model, enriched with a detailed government structure and a comprehensive array of fiscal tools. We then compare the effects of some relevant shocks to those generated by the Central Bank of Brazil's DSGE workhorse model, SAMBA. Additionally, we analyze several fiscal structural reforms that have been suggested or implemented within the last decade. Our results show that our model does a good job of reproducing the movements of key economic variables, shedding light on the fiscal dynamics and their interactions with monetary policy and external shocks. Introducing Stone–Geary (subsistence) preferences for non-Ricardian households strengthens empirical realism without altering our main conclusions.

Keywords Small open economy · Fiscal policy · Distortionary taxation · National accounting · DSGE model

JEL Classification E32 · E60 · F41 · H62 · H30

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1 Introduction

Emerging markets and developing economies often confront significant challenges concerning the sustainability of their fiscal policies, especially amidst high economic volatility and pressing social needs. Effective governance is then somehow compromised in the face of frequent and intense shocks hitting these economies. In light of these difficulties, policymakers in these countries should rely on robust models to diagnose the problems and make informed decisions about the more fitting measures to promote economic growth and social justice. Any sound analysis seeking to assess the impact of fiscal reforms and shocks on economic activity should thus be grounded in models of sufficient rigor and depth.

This article attempts to accomplish that task by putting forth a DSGE model that provides a comprehensive framework for understanding and predicting the interactions between shocks and overall economic performance in emerging markets and small open economies more broadly[1]. This setup features an open economy where the fiscal block is thoroughly detailed so as to capture the complexities of government policy and its impacts. It incorporates various fiscal instruments, allowing for the examination of policy responses under different economic conditions.

This fiscal module draws from the System of National Accounts (SNA)-compliant structure embeded into an otherwise frictionless DSGE model developed by de-Córdoba et al. (2025). We believe the advantages of such an approach are several-fold:

1. DSGE models usually employ simplifying frameworks on the fiscal front, which may omit relevant transmission mechanisms. Our model, however, incorporates a detailed government sector as defined by the SNA, fully representing the breadth and diversity of government activities and their impact on the economy.
2. The detailed representation of the government sector enables the model to better assess the economy-wide impact of specific components of public expenditure and taxation. It provides a valuable perspective for evaluating fiscal consolidation measures, making it a useful tool for policymakers.
3. The model's compliance with SNA makes it suitable for use in international comparisons and studies, adhering to the data collection and reporting standards of major organizations like the OECD or the IMF.

The model's fiscal unit incorporates a rich variety of taxes and government expenditures. Distortionary taxes include those on consumption, imports, labor income, and capital income. Additionally, the model encompasses social security contributions from households and firms, as well as lump-sum taxes. On the expenditure side, it covers current spending, infrastructure investment, and public wages.

In addition to that, we explicitly account for the following frictions or building blocks:

[1] While the model is particularly relevant for non-developed economies, it is not exclusively restricted to them.

1. Consumer heterogeneity: Ricardian versus non-Ricardian (or hand-to-mouth) households.
2. Habit formation in consumption.
3. Price and private wage rigidity.
4. Investment adjustment costs.
5. International trade in both final and intermediate goods and services, as well as in financial assets.

In order to credibly assess the validity of our SOE-TANK (Small Open Economy Two-Agent New Keynesian) model, we compare its results to those generated by the Central Bank of Brazil (BCB)'s well-known workhorse DSGE model, SAMBA (Stochastic Analytical Model with a Bayesian Approach)[2]. This comparison allows us to verify that our model's performance aligns well with most of the outcomes that the widely used BCB model yields. The advantage of our SNA-compliant DSGE model over SAMBA lies primarily in its more detailed fiscal framework, allowing users to conduct thorough analyses of fiscal shocks and their ensuing effects. We believe that it constitutes a powerful tool for the careful examination of much-needed reforms and policies in emerging markets.

As alluded to above, the results of our experiments are, by and large, quite satisfactory. For the same shocks included in Castro et al. (2015), we find that most of the variables across both models exhibit similar behavior. As for the shocks not included in the aforementioned article, all of which are fiscal in nature, the impulse response functions (IRFs) generally offer realistic patterns and reliable representations of the economic dynamics. Some Brazil-specific policies were also simulated, such as the 'administrative reform'– which is at the forefront of Brazil's policy debate and features in daily news coverage–, reducing the wage premium of the public sector vis-à-vis the private sector, revealing important insights on efficient resource allocation, productivity gains, and welfare transfers among different household groups[3].

As a robustness check, we incorporate Stone–Geary (subsistence) preferences for non-Ricardian households, which enhance the model's empirical realism. Results do not materially change, confirming that our findings are not driven by this specification.

This work contributes to the literature on DSGE models applied to emerging economies and small open developed economies by presenting a novel approach and showcasing the potential practical relevance of its results for economic policy. In addition to this introductory section, this paper is organized as follows: Section 2 examines the literature review, Section 3 describes the model, Section 4 presents a detailed discussion about the results, Section 5 implements a robustness exercise including Stone-Geary preferences, and Section 6 concludes.

[2] For this comparative analysis, we rely solely on the shocks studied in the published article where SAMBA was presented (Castro et al. 2015).

[3] The analysis of the 'emergency aid payment' –a lump-sum transfer to household to help them cope with the pandemic shock– is not shown as it constitutes a pure income effect with an expected outcome. Results are available upon request.

2 Literature Review

The relationship between fiscal policy and macroeconomic performance has sparked intense academic debate, especially in the aftermath of recent economic crises. This literature review aims to synthesize key theoretical and empirical contributions, exploring how different fiscal measures, such as government consumption, government investment, and taxes, affect the relevant macroeconomic variables in a small open economy, with a focus primarily on the short to medium run.

The international literature is rich in studies on fiscal policy effects, yet there remains no consensus on the size of government spending multipliers. Ramey (2019) provides a comprehensive summary of the debate, concluding that most estimates place government spending multipliers within a range of 0.6 to 1[4]. By the same token, the size of tax multipliers hinges on the methodology employed: narrative methods tend to produce sizeable multipliers around -2 to -3, whereas DSGE models entail smaller multipliers, typically below one.

Early studies using flexible-price optimization models, such as Airagayi et al. (1992); Rotemberg and Woodford (1992), and Baxter and King (2025), showed that increased government spending reduces household wealth by raising the present discounted value of future taxes. This wealth effect prompts households to increase labor supply and decrease private consumption. The former article also demonstrate that persistent shocks have a larger impact on output, employment and interest rates compared to temporary ones, challenging previous works, such as Hall (1980) and Barro (1981, 1987). Subsequent New Keynesian models, building upon these flexible-price frameworks, usually incorporated both real and nominal frictions. While this class of models reproduce the same fiscal-induced increase in hours worked –provided that workers are not off their labor curves —- they often predict higher real wages, driven by more elevated labor demand (Woodford 2003; Galí 2015).

Recent developments in fiscal policy modeling have highlighted consumer heterogeneity as a crucial factor, moving away from the the restrictive assumption of the representative agent (RA). Differences in income, wealth, and consumption preferences across households can significantly influence the transmission of fiscal shocks, affecting labor supply responses, consumption patterns, and ultimately the magnitude of fiscal multipliers. Campbell and Mankiw (1989) pioneered this shift by distinguishing between Permanent-Income-Hypothesis (PIH) consumers and rule-of-thumb (ROT) ones, the latter lacking access to financial markets.

Building on this insight, Galí et al. (2007) incorporate ROT agents into an otherwise standard New Keynesian model, demonstrating that fiscal stimuli have significant positive effects on consumption, output, employment, and real wages in the short run. Likewise, Forni et al. (2009) identify 30-40% of agents as non-Ricardian, observing mild Keynesian effects of fiscal policy. While government spending and public employee compensation have limited, short-lived effects on private consumption, household transfers exhibit more durable impacts. Tax reductions, particularly on labor and consumption, significantly enhance consumption and output, and cuts in

[4] Although this range reflects significant variation across different methodologies and economic contexts.

capital income tax drive medium-term investment and growth. However, fiscal policy contributes minimally to cyclical macroeconomic fluctuations.

Further advancing this line of inquiry, Bilbiie et al. (2024) examine the effects and transmission of fiscal policy in a sticky-price DSGE model featuring non-Ricardian agents, distortionary taxation, and a Walrasian labor market. Their analysis highlights how non-Ricardian households amplify fiscal shocks by consuming their entire disposable income. The study also investigates the differences between lump-sum and distortionary taxation in financing government spending, showing that these choices have significant implications for the magnitude and persistence of fiscal multipliers.

Expanding on this, Bilbiie (2009) examines nonseparable preferences over consumption and leisure as a mechanism for explaining fiscal policy puzzles, such as the positive co-movement of consumption and hours worked after fiscal shocks. The study finds that nonseparable preferences can replicate observed consumption patterns, but this result depends on restrictive assumptions, such as consumption behaving as an inferior good. In subsequent studies, Bilbiie's works (2011, 2020) explore the role of nonseparable preferences between consumption and leisure in determining fiscal policy outcomes. The 2011 paper demonstrates how Edgeworth substitutability and sticky prices can generate positive consumption multipliers through shifts in labor demand, while the 2020 study expands this by analyzing utility functions like GHH and CRRA and their effects on labor supply elasticity and fiscal transmission. Together, these studies point to the critical interplay between preference specifications, labor dynamics, and structural model features in explaining and enhancing fiscal policy effectiveness.

Distinguishing between different classes of government spending is crucial for understanding the output effects of fiscal policy. Leeper et al. (2010) analyze the macroeconomic effects of government investment through a neoclassical growth model, emphasizing that implementation delays weaken the short-term stimulative impact on output and employment. They show that the fiscal financing method–whether through distortionary taxes, transfers, or government consumption–significantly shapes long-term outcomes. Distortionary taxes hinder growth, while reducing lump-sum transfers minimizes adverse effects. Crucially, the productivity of public capital determines fiscal multiplier effectiveness, with higher productivity leading to more favorable economic results. Building on these insights, Ramey (2021) incorporates both neoclassical and New Keynesian frameworks to study the macroeconomic consequences of infrastructure investment. While she reaffirms the short-term limitations caused by implementation delays and time-to-build lags, her analysis highlights how infrastructure spending can substantially boost output and productivity in the long run, particularly when public capital is below its optimal level.

In an application to the UK, Bhattarai and Trzeciakiewicz (2017) emphasize that these two-agent models analyze both short- and long-term effects of fiscal instruments, such as public consumption and investment, and assess their effectiveness under different economic conditions, including scenarios where interest rates are constrained by the zero lower bound (ZLB). It finds that government consumption and public investment have the highest short-term multipliers (0.97 and 1.08, respectively), while capital income taxes and public investment drive long-term growth. Nominal rigidities amplify the impact of public spending but weaken income tax effects. At the zero lower bound, public consumption and investment become more effective, while tax policies lose impact.

Parallel to these theoretical advancements, empirical research has provided further validation. Bilbiie et al. (2008) compared fiscal policy effects in the U.S. economy across two periods (1957-1979 and 1983-2004). They observed stronger fiscal multipliers before the 1980s, attributing this to lower asset market participation and a less active monetary policy stance in the earlier period.

Drawing on more sophisticated setups, such as incomplete-market models, Werning (2015) analyze optimal fiscal policy under under conditions of market incompleteness, emphasizing its impact on redistribution and stabilization. Recent developments in this realm, particularly Heterogeneous Agent New Keynesian (HANK) models, allow for richer household heterogeneity. Notable contributions by Auclert et al. (2024) and Hagedorn et al. (2019) highlight the redistribution channels of fiscal policy and the role of unemployment benefits in fiscal multiplier changes, while Bilbiie and Straub (2004) stress how fiscal policy interacts with stabilization and redistribution objectives.

McKay and Reis (2016) investigate how incomplete markets and heterogeneous households in a HANK setup affect fiscal multipliers. They found that fiscal spending financed by lump-sum taxes can be highly effective in stimulating aggregate demand, especially in economies with significant income inequality and imperfect insurance mechanisms. Similarly, in the context of the Covid-19 pandemic, Bayer et al. (2023) develop a HANK model with nominal wage rigidities and financial market imperfections, showing that transfer multipliers vary a lot in the short-run: it is nil for unconditional transfers and close to one for conditional transfers. Besides, they find that the transfers dampened the output loss due to the pandemic by some two percentage points at its trough.

When it comes to open economies, Ravn et al. (2008) explore state-dependent fiscal multipliers, showing that fiscal policies are more effective during liquidity traps and periods of financial stress, where monetary policy constraints make households highly responsive to government spending. Born et al. (2024) address the effects of government spending on economic activity and the real exchange rate in open economies, underlining asymmetric responses under downward nominal wage rigidity (DNWR) and different exchange rate regimes. Under fixed exchange rates, positive fiscal shocks appreciate the real exchange rate, while negative shocks reduce output and employment. Empirical evidence supports these findings, showing that dynamic tax adjustments, like payroll taxes, can mitigate fiscal asymmetries.

Studies using DSGE models show that expansive fiscal policies can have significant effects on GDP during economic crises, especially when the zero lower bound (ZLB) binds. Woodford (2011) posits that in normal times, the government-spending multiplier is smaller than one. However, when monetary policy is constrained by the ZLB, the multiplier can exceed one, as fiscal spending reduces real interest rates and stimulates aggregate demand more effectively. Christiano et al. (2011) show that the government spending multiplier can exceed one, and even reach 3.7, when nominal interest rates are at the ZLB. In such scenarios, fiscal spending lowers real interest rates, boosting private demand.

Similarly, Eggertsson (2011) finds that traditional supply-side fiscal measures, such as cuts in labor or capital taxes, can be contractionary under these conditions, as they create deflationary pressures that raise real interest rates. In contrast, demand-side policies, such as temporary increases in government spending or cuts in sales taxes, are highly effective at stimulating output. Along these lines, Coenen et al. (2012) estimate that discretionary fiscal measures implemented during the global financial crisis raised the annualized growth rate of real quarterly GDP by up to 1.6 percentage points.

Jo and Zubairy (2025) analyze how government spending multipliers depend on the state of the economy and whether downturns are demand- or supply-driven. Using a New Keynesian model with DNWR, they show that fiscal multipliers are larger during demand-driven recessions with low inflation, as DNWR prevents wage cuts, reducing crowding-out effects. Conversely, supply-driven recessions weaken multipliers due to rising inflation. However, the effectiveness of these policies crucially hinges on coordination with monetary policy and the specific economic context (Davig and Leeper 2011; Leeper et al. 2017).

Turning to fiscal consolidation exercises, Coenen et al. (2008) study the macroeconomic effects of fiscal consolidation in the euro area using the New Area-Wide DSGE Model (NAWM). The findings reveal that while fiscal consolidation yields long-term benefits, such as higher output and lower debt servicing costs, it imposes short-term economic costs due to labor and product market rigidities. Expenditure-based and revenue-based strategies have distinct effects on consumption, labor supply, and investment, with distributional impacts disproportionately affecting financially constrained households. González-Astudillo et al. (2024) develop a small open economy DSGE model to investigate the macroeconomic effects of fiscal consolidation in commodity-exporting countries, with Ecuador as a case study. The model incorporates productive public capital, government consumption, transfers to constrained households, and various taxes. Through simulations of Ecuador's 2020-2025 fiscal consolidation program, they demonstrate how consolidation reduces the country risk premium and encourages private investment, while also causing a temporary 1% decline in GDP. Financially constrained households benefit from increased transfers, whereas unconstrained households face reduced consumption due to higher labor taxes.

3 Model

3.1 Households

In this model, there is a continuum of households indexed by $j \in [0, 1]$. A fraction ω_R of these households, indexed by $R \in [0, \omega_R)$, can save and behave like Ricardian households, meaning they maximize their intertemporal utility. The remaining households, indexed by $NR \in [\omega_R, 1]$, simply consume their current disposable income and are referred to as non-Ricardian households.

3.1.1 Definition of Consumption and Savings for Ricardian Households

This representative household chooses consumption, savings, and leisure so as to maximize its intertemporal utility. Consumption includes domestically produced goods (subject to consumption tax) and imported goods (subject to import tax), with public services affecting the level of utility. Savings can be carried out in the form of domestic public bonds, external bonds, and physical assets (private investment). Finally, by choosing the number of working hours (in the private sector[5] or the government), the household also chooses leisure. This model differentiates labor in the utility function, allowing preferences to vary between sectors through different marginal disutilities of labor. Given these features, Ricardian households must solve the following problem:

$$\max_{C_t^{R,D,D},C_t^{R,F,D},L_t^{R,P},L_t^G,B_{t+1},B_{t+1}^F,K_{t+1}^P} E_t \sum_{t=0}^{\infty} \beta^t S_t^P \left[\frac{\left(C_t^R + \gamma_{servG} Serv_t^G\right)^{1-\sigma}}{1-\sigma} - S_t^L \left(\frac{L_t^{R,P\,1+\varphi_P}}{1+\varphi_P} + \Xi_G \frac{L_t^{G\,1+\varphi_G}}{1+\varphi_G} \right) \right] \tag{1}$$

subject to a budget constraint[6],

$$\begin{aligned}(1+\tau_t^C)C_t^{R,D,D}P_t^{C,D} + (1+\tau_t^{imp})C_t^{R,F,D}S_tP_t^{C,F} + I_t^P P_t^{C,D} + \frac{B_{t+1}}{R_t^B} + B_t^F S_t R_{t-1}^F \\ = (1-\tau_t^L-\tau_t^{H,S})(W_t^P L_t^{R,P} + W_t^G L_t^G) + (1-\tau_t^K)R_t^K K_t^P + B_t + B_{t+1}^F S_t \\ -\frac{\chi_F}{2}\left(B_{t+1}^F - B_{ss}^F\right)^2 S_t - \omega_R(T_t P_t^{C,D})\end{aligned} \tag{2}$$

where E_t is the rational expectations operator, β is the intertemporal discount parameter, σ is the relative risk aversion, φ_P and φ_G represent the marginal disutilities of labor in the private and government sectors, respectively, Ξ_G is an adjustment parameter for the public-private labor relationship, γ_{servG} is the parameter for the sensitivity of public service utility, C is consumption, $C^{R,D,D}$ is consumption of domestically produced goods[7], $C^{R,F,D}$ is consumption of foreign-produced goods, the prices[8] of these two goods are $P^{C,D}$ and $P^{C,F}$, respectively, I^P is private investment, $Serv^G$ is public service, B denotes domestic public bonds, with a return given by R^B, , and net external bonds[9] are represented by B^F with a return R_F, S is the nominal exchange rate, $L^{R,P}$ and L^G are the quantities of hours worked in the private and government sectors, respectively, with remunerations W^P and W^G, K^P

[5] There is an assumption of nominal rigidity in the private labor market, which is addressed separately.

[6] T_t is a per-household *real* lump-sum levy (units of the consumption good). Because the constraints are written in nominal terms, it appears as $P_t^{C,D}T_t$. Dividing the entire constraint by $P_t^{C,D}$ gives the equivalent real formulation; the group-level terms are $-\omega_R T_t$ (Ricardian) and $-(1-\omega_R)T_t$ (non-Ricardian). This is a change of units only and does not make the tax ad valorem nor tie it to any base.

[7] We use the following naming convention for consumption and input variables: $X^{A,B}$, where A represents where the product is produced and B represents where the product is consumed.

[8] We use the following naming convention for prices: $P^{A,B}$ where A represents the sector (C for consumer goods and INS for inputs) and B represents the country (D for domestic and F for the rest of the world).

[9] Acquisition of domestic bonds by foreign households minus acquisition of external bonds by domestic households.

is private capital with a return R^K. Taxes on domestic consumption, imported consumption, labor remuneration, capital service remuneration, social security contributions, and lump-sum (real) taxes are τ^C, τ^{imp}, τ^L, τ^K, $\tau^{H,S}$ and *T*, respectively. The term $\left[\frac{\chi_F}{2}\left(B^F_{t+1} - B^F_{ss}\right)^2 S_t\right]$ is used to induce model stationarity (Schmitt-Grohé and Uribe 2003).

The effective consumption index in utility is specified as a linear composite of private consumption and publicly provided services:

$$C_t^{eff} \equiv C_t^i + \gamma_{servG}\, Serv_t^G, \qquad i \in \{R, NR\}, \quad \gamma_{servG} \in (0,1).$$

Because this aggregator is linear inside CRRA preferences, private consumption, *C*, and public services, *Serv*, are treated as perfect substitutes across the two components (the implied elasticity of substitution is infinite). The marginal rate of substitution is constant:

$$\text{MRS}_{C,Serv} \equiv \frac{\partial U/\partial C}{\partial U/\partial Serv} = \frac{1}{\gamma_{servG}} \quad (\text{equivalently,} \text{MRS}_{Serv,C} = \gamma_{servG})^{10}.$$

We adopt this specification for three reasons. First, it offers a transparent bridge to the System of National Accounts (SNA),[10] where final consumption expenditure is the sum of household and government consumption, and avoids introducing an extra curvature parameter that is difficult to identify with available data. Second, it follows a well-established practice in macro-fiscal DSGE work where publicly provided services enter preferences additively or nonseparably (e.g., Baxter and King (2025); Galí et al. (2007); Leeper et al. (2010)). Third, calibrating $\gamma_{servG} < 1$ captures that one unit of publicly provided services yields less private utility than one unit of private consumption, reflecting congestion/quality differences and that some items in government consumption are not purely privately enjoyed.

Finally, under our specification, at the margin, one unit of publicly provided services yields γ_{servG} times the marginal utility of one unit of private consumption (both measured in consumption-good equivalents)[11]

[10] With $U(C^{eff}) = \frac{(C^{eff})^{1-\sigma}}{1-\sigma}$ and $C^{eff} = C + \gamma_{servG} Serv$, we have $MU_C = u'(C^{eff})$ and $MU_{Serv} = \gamma_{servG} u'(C^{eff})$, hence a constant MRS.

[11] As a robustness check, we also considered a CES composite,

$$C_t^{eff} = \left[(1-\alpha)\, C_t^{i\;\frac{\eta-1}{\eta}} + \alpha\,(\upsilon_{ces}\, Serv_t^G)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}},$$

where η is the elasticity of substitution between C_t^i and $\upsilon_{ces}\, Serv_t^G$, $\alpha \in (0,1)$ is the share parameter, and υ_{ces} rescales public services into consumption-good units. The specification nests several familiar cases: as $\eta \to \infty$ reproduces our linear (perfect-substitutes) benchmark; for $\eta = 1$, it reduces to Cobb-Douglas; and as $\eta \to 0$, it converges to Leontief. Across a wide grid of η values (including near the perfect-substitutes limit), we find that model moments change only modestly, leaving policy conclusions essentially unaffected. Full details are reported in Appendix B.

The model introduces two shocks on the household preference side. First, S^P is the intertemporal preference shock, altering the household's choice between present and future consumption, following the rule:

$$\log S_t^P = \rho_P \log S_{t-1}^P + \epsilon_{P,t} \tag{3}$$

where ρ_P is the autoregressive component, and $\epsilon_{P,t} \sim N(0, \sigma_P)$. The second shock is the labor supply shock, S^L, which affects the household's willingness to work. The rule governing this shock is:

$$\log S_t^L = \rho_L \log S_{t-1}^L + \epsilon_{L,t} \tag{4}$$

where ρ_L is the autoregressive component of this shock, and $\epsilon_{L,t} \sim N(0, \sigma_L)$.

We still need a capital accumulation rule, a labor aggregation, and a consumption aggregation:

$$K_{t+1}^P = (1-\delta)K_t^P + I_t^P \left[1 - \frac{\nu}{2}\left(\frac{I_t^P}{I_{t-1}^P S_t^I} - 1\right)^2\right] \tag{5}$$

where ν is the investment adjustment cost sensitivity parameter and S_t^I is the private investment productivity shock given by:

$$\log S_t^I = \rho_I \log S_{t-1}^I + \epsilon_{I,t} \tag{6}$$

where ρ_I is the autoregressive component, and $\epsilon_{I,t} \sim N(0, \sigma_I)$.

$$L_t^R = L_t^{R,P} + L_t^G \tag{7}$$

$$C_t^R = \bar{C_t^R} - \gamma_C \bar{C_{t-1}^R} \tag{8}$$

where γ_C is the habit formation parameter with aggregation:

$$\bar{C_t^R} = C_t^{R,D,D^{1-\omega_C^D}} C_t^{R,F,D^{\omega_C^D}} \tag{9}$$

First-order conditions for the problem are:

$$\left(\frac{1-\omega_C^D}{\omega_C^D}\right)\frac{C_t^{R,F,D}}{C_t^{R,D,D}} = \left(\frac{1+\tau_t^C}{1+\tau_t^{imp}}\right)\frac{P_t^{C,D}}{P_t^{C,F} S_t} \tag{10}$$

$$\left(\frac{1}{1-\omega_C^D}\right)\left[\frac{S_t^L \Xi_G L_t^{G^{\varphi_G}} C_t^{R,D,D}}{\left(C_t^R + \gamma_{servG} Serv_t^G\right)^{-\sigma} C_t^R}\right] = \left(\frac{1-\tau_t^L-\tau_t^{H,S}}{1+\tau_t^C}\right)\frac{W_t^G}{P_t^{C,D}} \tag{11}$$

$$\left[\frac{S_t^P\left(C_t^R+\gamma_{servG}Serv_t^G\right)^{-\sigma}C_t^R}{(1+\tau_t^C)P_t^{C,D}C_t^{R,D,D}}\right]=R_t^B\beta E_t\left[\frac{S_{t+1}^P\left(C_{t+1}^R+\gamma_{servG}Serv_{t+1}^G\right)^{-\sigma}C_{t+1}^R}{(1+\tau_{t+1}^C)P_{t+1}^{C,D}C_{t+1}^{R,D,D}}\right] \quad (12)$$

$$R_t^B=R_t^F E_t\left\{\frac{S_{t+1}}{S_t}\right\}\left[\frac{1}{1-\chi_F(B_{t+1}^F-B_{ss}^F)}\right] \quad (13)$$

$$Q_t=\beta E_t\left\{(1-\delta)Q_{t+1}+\left[\frac{(1-\omega_C^D)\left(C_{t+1}^R+\gamma_{servG}Serv_{t+1}^G\right)^{-\sigma}C_{t+1}^R}{(1+\tau_{t+1}^C)P_{t+1}^{C,D}C_{t+1}^{R,D,D}}\right]\left(R_{t+1}^K-P_{t+1}^{C,D}\right)\right\} \quad (14)$$

$$\left[\frac{(1-\omega_C^D)S_t^P\left(C_t^R+\gamma_{servG}Serv_t^G\right)^{-\sigma}C_t^R}{C_t^{R,D,D}}\right]=Q_t\left[1-\frac{\nu}{2}\left(\frac{I_t^P}{I_{t-1}^P S_t^I}-1\right)^2-\nu\left(\frac{I_t^P}{I_{t-1}^P S_t^I}\right)\left(\frac{I_t^P}{I_{t-1}^P S_t^I}-1\right)\right]$$

$$+\nu\beta E_t\left[Q_{t+1}\left(\frac{I_{t+1}^P}{I_t^P S_{t+1}^I}\right)^2\left(\frac{I_{t+1}^P}{I_t^P S_{t+1}^I}-1\right)\right] \quad (15)$$

where Q is the Lagrange multiplier associated with capital stock movement.

Equations 10-15 represent the relative consumption between domestic and imported goods, public labor supply, Euler equations for domestic and foreign bonds[12], physical capital, and private investment demand.

3.1.2 Definition of Consumption for Non-Ricardian Households

This representative non-Ricardian household maximizes its intertemporal utility by choosing consumption and leisure[13], restricted to intratemporal choices due to its liquidity constraint that prevents intertemporal maximization. Their consumption can be on domestically produced goods ($C_t^{NR,D,D}$) (subject to consumption tax) and imported goods ($C_t^{NR,F,D}$) (subject to import tax), with public services affecting the level of utility. Given these features, non-Ricardian households must solve the following problem:

$$\max_{C_t^{NR,D,D},C_t^{NR,F,D},L_t^{NR,P}} E_t\sum_{t=0}^{\infty}\beta^t S_t^P\left[\frac{\left(C_t^{NR}+\gamma_{servG}Serv_t^G\right)^{1-\sigma}}{1-\sigma}-S_t^L\frac{L_t^{NR,P^{1+\varphi_P}}}{1+\varphi_P}\right] \quad (16)$$

subject to a budget constraint,

$$(1+\tau_t^C)C_t^{NR,D,D}P_t^{C,D}+(1+\tau_t^{imp})C_t^{NR,F,D}S_tP_t^{C,F}$$

$$=(1-\tau_t^L-\tau_t^{H,S})W_t^PL_t^{NR,P}-(1-\omega_R)(T_tP_t^{C,D})+(1-\omega_R)TR_tP_t^{C,D} \quad (17)$$

with,

[12] Uncovered interest rate parity (UIP).

[13] Unlike Ricardian households, non-Ricardian households do not supply labor to the public sector.

$$C_t^{NR} = C_t^{\bar{N}R} - \gamma_C C_{t-1}^{\bar{N}R} \tag{18}$$

$$C_t^{\bar{N}R} = C_t^{NR,D,D^{1-\omega_C^D}} C_t^{NR,F,D^{\omega_C^D}} \tag{19}$$

TR_t is a real lump-sum per-household transfer which are exclusively targeted to the non-Ricardian households.

The first-order condition for the previous problem is:

$$\left(\frac{1-\omega_C^D}{\omega_C^D}\right) \frac{C_t^{NR,F,D}}{C_t^{NR,D,D}} = \left(\frac{1+\tau_t^C}{1+\tau_t^{imp}}\right) \frac{P_t^{C,D}}{P_t^{C,F} S_t} \tag{20}$$

3.1.3 Definition of Private Wage (Ricardian and Non-Ricardian Households)

The choice of the private wage level by both Ricardian and non-Ricardian households implies that these agents provide differentiated labor under a monopolistic competition framework. These services are sold to a representative labor aggregator, which combines all these different labor services ($L_j^{Z,P}$) into a single input ($L^{Z,P}$) through a Dixit-Stiglitz technology (Dixit and Stiglitz 1977), where $Z := \{R, NR\}$.

$$\max_{L_{j,t}^{Z,P}} W_t^P L_t^{Z,P} - \int_0^1 W_{j,t}^P L_{j,t}^{Z,P} dj \tag{21}$$

subject to the following technology:

$$L_t^{Z,P} = \left(\int_0^1 L_{j,t}^{Z,P \frac{\psi_{W,t-1}}{\psi_{W,t}}} dj\right)^{\frac{\psi_{W,t}}{\psi_{W,t-1}}} \tag{22}$$

where $\psi_{W,t}$ is the elasticity of substitution between different labor types, whose movement follows:

$$\log \psi_{W,t} = \rho_{\psi_W} \log \psi_{W,t-1} + \epsilon_{\psi_W,t} \tag{23}$$

where ρ_{ψ_W} is the autoregressive component of this shock and $\epsilon_{\psi_W,t} \sim N(0, \sigma_{\psi_W})$.

The first-order condition for the previous problem is:

$$L_{j,t}^{Z,P} = L_t^{Z,P} \left(\frac{W_t^P}{W_{j,t}^P}\right)^{\psi_{W,t}} \tag{24}$$

This equation represents the demand for the labor of household *j*. Substituting this expression into Eq. 22 results in the aggregate wage level:

$$W_t^P = \left(\int_0^1 W_{j,t}^{P\ 1-\psi_W} dj \right)^{\frac{1}{1-\psi_W}} \tag{25}$$

Additionally, each period, a fraction $1-\theta_W$ of households -chosen randomly and independently– set their wages optimally. The remaining households, θ_W, follow a fixed wage rule ($W_{j,t}^P = W_{j,t-1}$). When setting their wage level in period *t* households that set wages are aware of the probability θ_W^N that the wage will remain fixed for *N* periods into the future, regardless of the household making the optimal choice $W_{j,t}^{P\,*}$ in the current period. Therefore, the household seeks to solve the following problem:

$$\max_{W_{j,t}^{P\,*}} E_t \sum_{i=0}^{\infty} (\beta\theta_W)^i \left\{ -S_{t+i}^P S_{t+i}^L \frac{L_{j,t+i}^{Z,P\ 1+\varphi_p}}{1+\varphi_p} - \lambda_{Z,t+i} \left[-W_{j,t}^{P\,*} L_{j,t+i}^{Z,P} \left(1 - \tau_{t+i}^L - \tau_{t+i}^{H,S} \right) \right] \right\} \tag{26}$$

subject to the labor demand of household *j* (Eq. 24).

Solving this problem yields the following first-order condition for both Ricardian and non-Ricardian households:

$$W_{j,t}^{P\,*} = \left(\frac{\psi_{W,t}}{\psi_{W,t}-1} \right) E_t \sum_{i=0}^{\infty} (\beta\theta_W)^i \left[\frac{S_{t+i}^P S_{t+i}^L L_{j,t+i}^{Z,P\ \varphi_p}}{\lambda_{Z,j,t+i}(1-\tau_{t+i}^L - \tau_{t+i}^{H,S})} \right] \tag{27}$$

where $markupW_t = \left(\frac{\psi_{W,t}}{\psi_{W,t}-1} \right)$.

Since $1-\theta_W$ of households set the same nominal wage, $W_{j,t}^{P\,*} = W_t^{P*}$, and the remaining θ_W, receive the same wage as the previous period, the aggregate nominal wage can be written as follows:

$$W_t^P = \left[\theta_W W_{t-1}^{P\ \ 1-\psi_{W,t}} + (1-\theta_W) W_t^{P*1-\psi_{W,t}} \right]^{\frac{1}{1-\psi_{W,t}}} \tag{28}$$

The gross wage inflation rate can be defined as:

$$\pi_{W,t} = \frac{W_t^P}{W_{t-1}^P} \tag{29}$$

3.1.4 Aggregating consumption and labor

The aggregate values for consumption and labor are given by:

$$C_t = \omega_R C_t^R + (1-\omega_R) C_t^{NR} \tag{30}$$

$$L_t^P = \omega_R L_t^{R,P} + (1-\omega_R) L_t^{NR,P} \tag{31}$$

3.2 Firms

3.2.1 Final Goods Producing Firms

From an aggregate perspective, monopolistic competition involves, among other things, the fact that consumers purchase a wide variety of goods. However, for modeling purposes, it is assumed that they buy only one specific (aggregate) good. This good is sold by final goods producing firms under a perfect competition structure.

To produce this aggregate good, the firm must buy a large quantity of intermediate goods. These are the inputs used in this production process. Therefore, the firm must solve the following problem:

$$\max_{Y_{j,t}} P_t^{C,D} Y_t - \int_0^1 P_{j,t}^{C,D} Y_{j,t} dj \tag{32}$$

subject to the following technology given by the Dixit-Stiglitz aggregator,

$$Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\psi_t - 1}{\psi_t}} dj \right)^{\frac{\psi_t}{\psi_t - 1}} \tag{33}$$

where Y_t is the final (aggregate) product in period *t* whose price is $P_t^{C,D}$, and $Y_{j,t}$ for $j \in [0, 1]$ is the intermediate good *j* with price $P_{j,t}^{C,D}$. And $\psi > 1$ is the elasticity of substitution between intermediate goods, whose movement follows:

$$\log \psi_t = \rho_\psi \log \psi_{t-1} + \epsilon_{\psi,t} \tag{34}$$

where ρ_ψ is the autoregressive component of this shock and $\epsilon_{\psi,t} \sim N(0, \sigma_\psi)$.

Solving the previous problem yields the demand for the product $Y_{j,t}$:

$$Y_{j,t} = Y_t \left(\frac{P_{j,t}^{C,D}}{P_t^{C,D}} \right)^{-\psi_t} \tag{35}$$

substituting Eq. 35 into Eq. 33, we arrive at the general price level:

$$P_t^{C,D} = \left(\int_0^1 P_{j,t}^{C,D\,1-\psi_t} dj \right)^{\frac{1}{1-\psi_t}} \tag{36}$$

3.2.2 Intermediate Goods Producing Firms

Considering that domestic production is given by $Y = \{C^{D,D}, I^P, G, I^G, C^{D,F}\}$, an intermediate goods producing firm solves its problem in three stages: first, it chooses private labor and private capital for the production of domestic inputs–public capital enters the production function as a given input; next, to determine its production level, it chooses between domestic and imported inputs; finally, it sets the price of the good it produces.

In the first stage, the firm operates under perfect competition and produces a domestic input, $INS_{j,t}^{D}$, using the following technology:

$$INS_{j,t}^{D} = A_t \left[\alpha_1^{\frac{1}{\psi_f}} K_{j,t}^{P\,\frac{\psi_f - 1}{\psi_f}} + \alpha_2^{\frac{1}{\psi_f}} L_{j,t}^{P\,\frac{\psi_f - 1}{\psi_f}} + \alpha_3^{\frac{1}{\psi_f}} K_{j,t}^{G\,\frac{\psi_f - 1}{\psi_f}} \right]^{\frac{\psi_f}{\psi_f - 1}} \tag{37}$$

where α_1, α_2 and α_3 are the shares of private capital, private labor, and public capital in the production of the domestic input, ψ_f is the elasticity of substitution between these inputs, and A_t captures the technological level of the economy, with the following law of motion:

$$\log A_t = \rho_A \log A_{t-1} + \varepsilon_{A,t} \tag{38}$$

where $\varepsilon_{A,t} \sim N(0, \sigma^A)$.

Thus, the firm's problem is to minimize its production cost subject to a tax on hiring labor, $\tau_t^{F,s}$:

$$\min_{K_{j,t}^P, L_{j,t}^P} (1 + \tau_t^{F,s}) W_t^P L_{j,t}^P + R_t^K K_{j,t}^P \tag{39}$$

subject to the technology given in Eq. 37.

The first-order conditions for the previous problem are:

$$\frac{(1 + \tau_t^{F,S}) W_t^P}{P_t^{INS,D}} = \left(\alpha_2 \frac{INS_{j,t}^D}{L_{j,t}^P} \right)^{\frac{1}{\psi_f}} \tag{40}$$

$$\frac{R_t^K}{P_t^{INS,D}} = \left(\alpha_1 \frac{INS_{j,t}^D}{K_{j,t}^P} \right)^{\frac{1}{\psi_f}} \tag{41}$$

The domestically produced input is used domestically, $INS^{D,D}$, or used abroad, $INS^{D,F}$, so:

$$INS_t^D = INS_t^{D,D} + INS_t^{D,F} \tag{42}$$

In the second stage, the firm must decide between using domestic and imported inputs through the following technology:

$$Y_{j,t} = INS_t^{D,D^{1-\omega_{INS}^D}} INS_t^{F,D^{\omega_{INS}^D}} \tag{43}$$

where ω_{INS}^{D} represents the share of imported input in the production of the intermediate good.

Therefore, the intermediate goods producing firm's problem (at this stage, firms also pay the ITF) at this stage is:

$$\min_{INS_{j,t}^{D,D},INS_{j,t}^{F,D}} INS_{j,t}^{D,D}P_t^{INS,D} + INS_{j,t}^{F,D}S_tP_t^{INS,F} \tag{44}$$

subject to the technology given in Eq. 45.

Solving the previous problem, we arrive at the following first-order conditions:

$$INS_{j,t}^{D,D} = (1-\omega_{INS}^{D})CM_{j,t}\left[\frac{Y_{j,t}}{P_t^{INS,D}}\right] \tag{45}$$

and,

$$INS_{j,t}^{F,D} = \omega_{INS}^{D}CM_{j,t}\left[\frac{Y_{j,t}}{S_tP_t^{INS,F}}\right] \tag{46}$$

The third stage of the intermediate goods producing firm's problem is to set the price of its good. This firm decides how much to produce each period according to a Calvo rule (Calvo 1983). There is a probability θ that the firm will keep the price of the good fixed in the next period ($P_{j,t} = P_{j,t-1}^{C,D}$) and the probability $(1-\theta)$ of setting the price optimally ($P_{j,t}^{C,D*}$). Once the price is set in period *t*, there is a probability θ that this price will remain fixed in period $t+1$, a probability θ^2 that this price will remain fixed in period $t+2$, and so on. Therefore, the firm must consider these probabilities when setting the price of its good. The firm's problem that adjusts the good's price in period *t* is:

$$\max_{P_{j,t}^{C,D*}} E_t\sum_{i=0}^{\infty}(\beta\theta)^i(P_{j,t}^{C,D*} - CM_{j,t+i})Y_{j,t+i} \tag{47}$$

subject to the demand for the good $Y_{j,t}$ Eq. 35.

Then, we arrive at the following first-order condition:

$$P_{j,t}^{C,D*} = \left(\frac{\psi_t}{\psi_t - 1}\right)E_t\sum_{i=0}^{\infty}(\beta\theta)^iCM_{j,t+i} \tag{48}$$

where $markupP_t = \left(\frac{\psi_t}{\psi_t-1}\right)$.

It is important to note that all intermediate goods producing firms that set their prices share the same markup over the same marginal cost. This means that in every period, $P_{j,t}^{C,D*}$ the price is the same for all firms $(1-\theta)$ that adjust their prices. Combining the pricing rule Eq. 36 with the assumption that all firms that change prices set an equal price, and that firms keeping prices constant do not affect the price–since they share the same technology–results in the overall final price level:

$$P_t^{C,D} = \left[\theta P_{t-1}^{C,D\,1-\psi_t} + (1-\theta) P_t^{C,D*\,1-\psi_t}\right]^{\frac{1}{1-\psi_t}} \tag{49}$$

3.3 Government

In this model, the government is divided into two different entities: the fiscal authority and the monetary authority. The former is responsible for conducting fiscal policy, while the latter seeks price stability through a Taylor rule. Additionally, the government is responsible for producing a service that is consumed by households at no cost.

3.3.1 Fiscal Authority

The fiscal authority is tasked with taxing and issuing debt to finance its expenditures, namely: current expenses, G_t; public investment, I_t^G; payroll, $L_t^G W_t^G$; and lump-sum transfers, $(1-\omega_R)TR_t$. Therefore, the government's budget constraint can be depicted as:

$$\frac{B_{t+1}}{R_t^B} - B_t + Taxes_t = P_t^{C,D} G_t + P_t^{C,D} I_t^G + L_t^G W_t^G + (1-\omega_R) P_t^{C,D} TR_t. \tag{50}$$

Total taxation is given by:

$$Taxes_t = \tau_t^C P_t^{C,D}(C_t^{R,D} + C_t^{NR,D}) + \tau_t^{imp} P_t^{C,F} S_t (C_t^{R,F} + C_t^{NR,F})$$

$$+ \left[(\tau_t^L + \tau_t^{H,S} + \tau_t^{F,S})(W_t^P L_t^{R,P} + W_t^P L_t^{NR,P}) + (\tau_t^L + \tau_t^{H,S}) W_t^G L_t^G\right] + \tau_t^K R_t^K K_t^P + T_t P_t^{C,D} \tag{51}$$

Since 1999, Brazil has resorted to the primary surplus regime of the non-financial public sector to stabilize the public sector net debt-to-GDP ratio. For this purpose, following Fernández-Villaverde et al. (2015), except for the ITF, all fiscal policy instruments follow the same public debt sustainability rule:

$$\frac{Z_t}{Z_{ss}} = \left(\frac{Z_{t-1}}{Z_{ss}}\right)^{\gamma_Z} \left(\frac{B_t}{Y_{t-1} P_{t-1}} \quad \frac{Y_{ss} P_{ss}}{B_{ss}}\right)^{(1-\gamma_Z)\phi_Z} S_t^Z \tag{52}$$

where γ_Z and ϕ_Z are parameters that capture the importance of these fiscal tools in public debt sustainability, and $Z = \{\tau_t^C, \tau_t^{imp}, \tau_t^L, \tau_t^{H,S}, \tau_t^{F,S}, \tau_t^K, T, (1-\omega_R)TR_t, I_t^G, W_t^G, G_t\}$.

The fiscal shock can be expressed as:

$$\log S_t^Z = \rho_Z \log S_{t-1}^Z + \varepsilon_{Z,t} \tag{53}$$

where $\varepsilon_{Z,t} \sim N(0, \sigma^Z)$.

The public capital stock evolves according to the following law of motion:

$$K_{t+1}^G = (1 - \delta_G) K_t^G + I_t^G \tag{54}$$

where δ_G denotes the depreciation rate of public capital.

The government is assumed to combine public spending on goods and services, G_t, and public labor, L_t^G, to produce public services, $Serv_t^G$, using the following production function:

$$Serv_t^G = G_t^{\alpha_G} L_t^{G\,1-\alpha_G} \tag{55}$$

where α_G indicates the share of public spending in the production of public services.

Public and private wages are *not* assumed equal in our framework. Private wages are set by households under Calvo frictions and therefore obey a wage Phillips curve (see the household block). By contrast, the *public-sector wage is administered* and features (i) a steady-state public-private premium and (ii) inertial dynamics with optional fiscal feedback.

We allow for a wage premium in levels,

$$W_{ss}^G \;=\; \Xi_G\, W_{ss}^P, \qquad \Xi_G > 0,$$

so the long-run level of public pay can differ systematically from private pay.

Around steady state, the public wage rule is specified in *log-deviations from the steady state*. Let $\widehat{x}_t \equiv \log x_t - \log x_{ss}$. Define the (demeaned) public debt-to-GDP gap as

$$\widehat{by}_{t-1} \;\equiv\; \log\!\left(\frac{B_{t-1}}{Y_{t-1} P_{t-1}^{C,D}}\right) \;-\; \log\!\left(\frac{B_{ss}}{Y_{ss} P_{ss}^{C,D}}\right).$$

The (nominal) public wage then follows

$$\widehat{w}_{G,t} = \gamma_{WG}\, \widehat{w}_{G,t-1} + (1 - \gamma_{WG})\, \phi_{WG}\, \widehat{by}_{t-1} + s_{WG,t}, \qquad s_{WG,t} \sim \mathcal{N}(0, \sigma_{WG}^2),$$

where $\gamma_{WG} \in (0, 1)$ governs inertia, ϕ_{WG} allows feedback to the lagged debt-to-GDP gap, and $s_{WG,t}$ is a policy shock.

Given (W_t^P, W_t^G), households optimally allocate hours between sectors. The intra-household condition linking the wage gap to the relative disutility of work implies, in linearized form,

$$\varphi_P \,\widehat{\ell}_t^P - \varphi_G \,\widehat{\ell}_t^G \;=\; \widehat{w}_t^P - \widehat{w}_t^G,$$

which is the relationship implemented in our linear system (see the households' FOC for public vs. private hours).

In estimation, Ξ_G, γ_{WG} and the volatility of $s_{WG,t}$ are disciplined by the data. Our baseline sets $\phi_{WG} = 0$ (pure inertia); allowing $\phi_{WG} \neq 0$ in robustness checks leaves our main results unchanged.

3.3.2 Monetary Authority

The central bank's dual mandate is to promote output growth and achieve price stability. To fulfill this dual objective, it follows a simple Taylor rule:

$$\frac{R_t^B}{R_{ss}^B} = \left(\frac{R_{t-1}^B}{R_{ss}^B}\right)^{\gamma_R} \left[\left(\frac{\pi_t^{C,D}}{\pi_{ss}^{C,D}}\right)^{\gamma_\pi} \left(\frac{Y_t}{Y_{ss}}\right)^{\gamma_Y}\right]^{(1-\gamma_R)} S_t^m \tag{56}$$

where γ_Y and γ_π reflect the sensitivities of the interest rate to output and inflation, respectively, γ_R is a smoothing parameter, and S_t^m is the monetary shock, which follows:

$$\log S_t^m = \rho_m \log S_{t-1}^m + \varepsilon_{m,t} \tag{57}$$

where $\varepsilon_{m,t} \sim N(0, \sigma^m)$.

3.4 Rest of the World's Economy

The exports of the domestic economy are considered homogeneous goods before they leave the dock but differentiated goods in the global market. The goods exported to the rest of the world include consumer goods and inputs used in the production process of the rest of the world.

3.4.1 Rest of the World's Households

There is a continuum of households in the rest of the world indexed by $j \in [0, 1]$. This representative household maximizes its intertemporal utility by choosing consumption of the exported good from the domestic country, $C^{D,F}$ or the good produced in the rest of the world, $C^{F,F}$:

$$\max_{C_{j,t}^{D,F}, C_{j,t}^{F,F}} E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{j,t}^{F\;1-\sigma}}{1-\sigma}\right) \tag{58}$$

with the following aggregation technology:

$$C_{j,t}^{F} = C_{t}^{F,F^{1-\omega_C^F}} C_{t}^{D,F^{\omega_C^F}} \tag{59}$$

subject to the following budget constraint,

$$C_t^{D,F} P_t^{C,D} + C_t^{F,F} S_t P_t^{C,F} = Y_t^F S_t P_t^{C,F} \tag{60}$$

The solution to the previous problem is:

$$\left(\frac{\omega_C^F}{1-\omega_C^F}\right)\left(\frac{C_t^{F,F}}{C_t^{D,F}}\right) = \frac{P_t^{C,D}}{S_t P_t^{C,F}} \tag{61}$$

3.4.2 Rest of the World's Intermediate Goods Production

In the production process of the rest of the world, imported inputs from the domestic economy and internally produced inputs are used:

$$\min_{INS_t^{D,F}, INS_t^{F,F}} INS_t^{D,F} P_t^{INS,D} + INS_t^{F,F} S_t P_t^{INS,F} \tag{62}$$

subject to,

$$Y_{j,t}^{F} = INS_t^{F,F^{1-\omega_{INS}^F}} INS_t^{D,F^{\omega_{INS}^F}} \tag{63}$$

The first-order conditions for the previous problem are:

$$\left(\frac{\omega_{INS}^F}{1-\omega_{INS}^F}\right)\left(\frac{INS_t^{F,F}}{INS_t^{D,F}}\right) = \frac{P_t^{INS,D}}{S_t P_t^{INS,F}} \tag{64}$$

3.4.3 Balance of Payments Equilibrium, Income Shocks, Interest Rates, and Prices in the Rest of the World

The balance of payments equilibrium is given by:

$$S_t\left(B_{t+1}^F - R_{t-1}^F B_t^F\right) = S_t\left[(C_t^{R,F,D} + C_t^{NR,F,D})\tau_t^{imp} P_t^{C,F} + INS_t^{F,D} P_t^{INS,F}\right] - \left(C_t^{D,F} P_t^{C,D} + INS_t^{D,F} P_t^{INS,D}\right) \tag{65}$$

The movement rules for global income, external interest rate, and the levels and prices of final goods and input imports are respectively:

$$\log Y_t^F = \rho_{Y^F} \log Y_{t-1}^F + \epsilon_{Y^F,t} \tag{66}$$

where $\epsilon_{Y^F,t} \sim N(0, \sigma_{Y^F})$.

$$\log R_t^F = \rho_{R^F} \log R_{t-1}^F + \epsilon_{R^F,t} \tag{67}$$

where $\epsilon_{R^F,t} \sim N(0, \sigma_{R^F})$.

$$\log P_t^{C,F} = \rho_{P^{C,F}} \log P_{t-1}^{C,F} + \epsilon_{P^{C,F},t} \tag{68}$$

where $\epsilon_{P^{C,F},t} \sim N(0, \sigma_{P^{C,F}})$.

$$\log P_t^{INS,F} = \rho_{P^{INS,F}} \log P_{t-1}^{INS,F} + \epsilon_{P^{INS,F},t} \tag{69}$$

where $\epsilon_{P^{INS,F},t} \sim N(0, \sigma_{P^{INS,F}})$.

4 Results

In presenting the results, the initial idea is to test the reliability of the model. Thus, impulse response functions (IRFs) for the model's "quality control" shocks are presented, comparing some shocks from our model with equivalent shocks from SAMBA (Castro et al. 2015)[14]. Therefore, we will focus on the analysis of four shocks (two supply-side and two demand-side shocks)[15]: productivity shock; price markup shock; monetary shock; and preference shock. Basically, the criterion used to determine if the shock results are similar involves the initial movement of the variable, the amplitude, and the time propagation of their effects[16].

Despite the similarities between the two models, they differ significantly in several aspects. While SAMBA develops an advanced pricing structure and simplifies fiscal issues, the SNA-compliant model's main feature is the fiscal side and uses basic price and wage frictions. Furthermore, the designs of the external sector differ between the models. In SAMBA, international trade occurs only in inputs used in the production of intermediate goods. In the SNA-compliant model, in addition to this trade in inputs, it is also possible to acquire imported consumer goods and export such

[14] Castro et al. (2015) developed the SAMBA model to be used as part of the macroeconomic modeling framework of the Central Bank of Brazil. The model incorporates: 1) a fiscal authority that targets an explicit primary surplus/GDP ratio, according to the fiscal regime in place since 1999; and 2) a significant portion of consumer prices regulated by the government, according to contractual rules. The model also includes two other less common features in DSGE models but relevant in the case of the Brazilian economy. First, in Brazil and many other countries with relatively large manufacturing sectors, most imports are inputs used in the production function rather than consumer goods. Therefore, the model treats imports as inputs used to produce differentiated sectoral goods. Second, the model assumes that a fraction of imports must be financed abroad, so that shocks to external financial conditions have an extra transmission channel to the domestic economy. Additionally, other frictions in SAMBA include wage and sectoral price rigidity, consumption habit persistence, non-Ricardian agents, and adjustment costs in investments, exports, and imports.

[15] Other equivalent shocks between the models are reported in the appendix of this paper.

[16] Green marks indicate that the effects are equivalent, while red marks indicate that they are not.

goods. Thus, in Figs. 1, 2, 3, 4, 5, 6, 7 and 8, the IRFs associated with international trade represent only input exchanges between the domestic and foreign countries. Another caveat is the timing of the models' estimations. SAMBA was estimated in 2011, while the SNA-compliant model was estimated in 2021 — much has changed in those ten years, especially on the fiscal side.

4.1 Productivity Shock

This subsection outlines a comparison of the temporary productivity shocks in the models, with an initial shock of 1% in both cases (Figs. 1 and 2). This shock influences the production of domestic inputs and their marginal cost (price of domestic inputs), operating through two main channels. The first channel is the *goods channel*, where the productivity gain boosts the production of domestic inputs. This increase in production means less labor is required to maintain the same level of output. Since domestic inputs affect the production of intermediate goods, their increase positively impacts aggregate demand. The second channel is the *cost channel*. Higher productivity reduces the marginal cost of producing domestic inputs. As these inputs are used in the production of intermediate goods, the price of intermediate goods falls, which in turn reduces consumer inflation (via the Phillips curve). Consequently, following the Taylor rule, the interest rate decreases.

Overall, the two models generate broadly similar responses: output rises by about 0.2% in the SNA-compliant model, which is within the acceptance range of SAMBA,

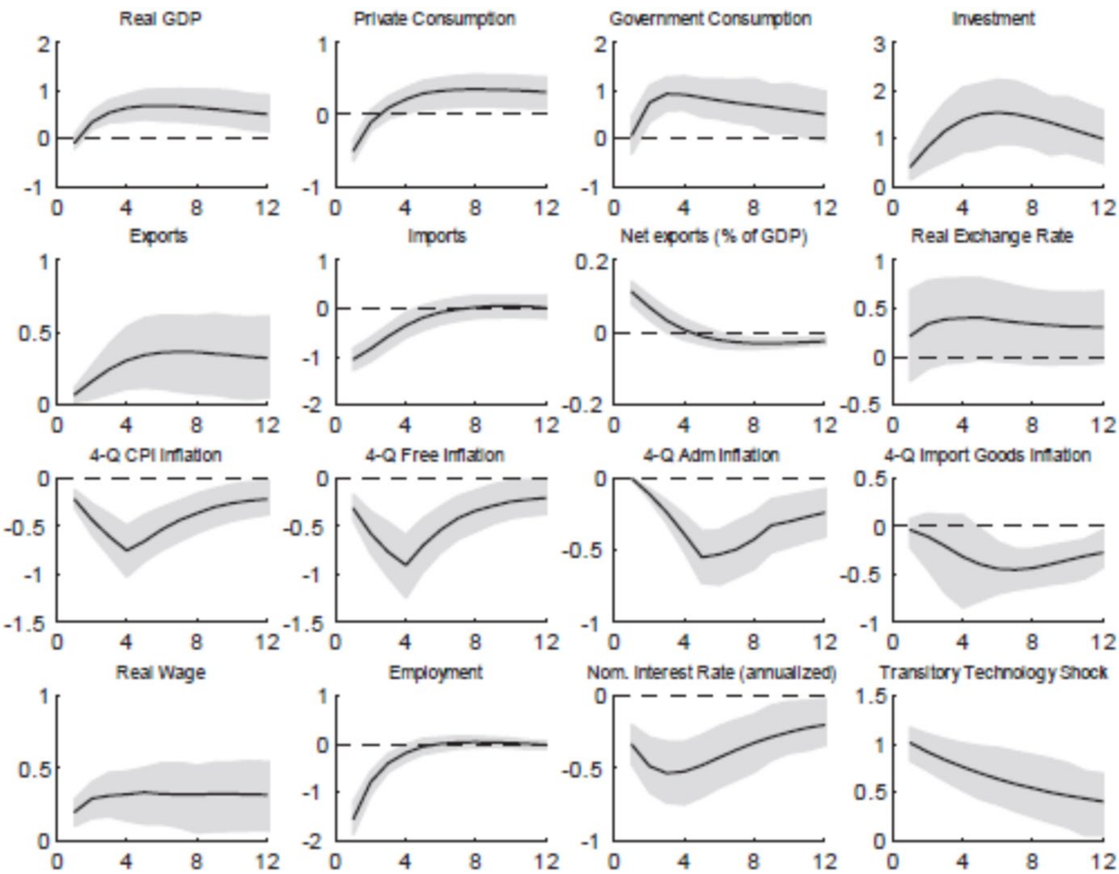

Fig. 1 IRF of the productivity shock in SAMBA. Source: Castro et al. (2015)

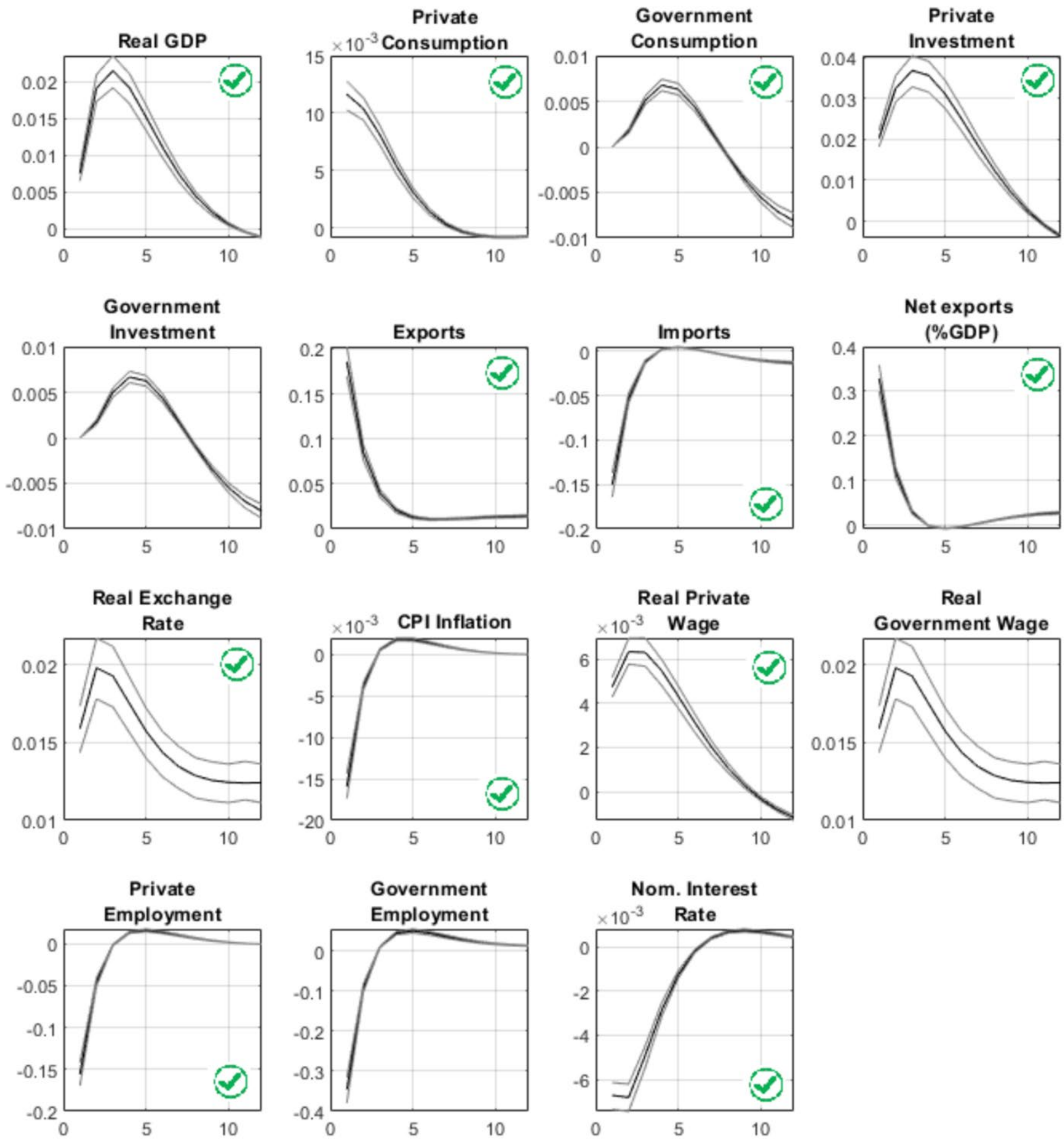

Fig. 2 IRF of the productivity shock in the SNA-compliant model. Source: Authors' elaboration

and employment falls by roughly 1% in both cases, returning to steady state within a few periods. The main differences arise in private consumption, government consumption, and private investment, which in our model display smaller and less persistent fluctuations. In particular, SAMBA exhibits a negative impact effect on private consumption that our model does not reproduce. We identify three plausible mechanisms behind this divergence that are consistent with this dynamics:

1. *Monetary-policy inertia.* SAMBA's Taylor rule features stronger interest-rate smoothing (posterior median $\gamma_R \approx 0.79$, 95% CrI 0.74–0.85) than in our model ($\gamma_R \approx 0.65$). For the same disinflation, SAMBA's more inertial rule implies a smaller nominal-rate cut, so the ex-ante real rate $r_t^e = i_t - E_t\pi_{t+1}$ rises more relative to the natural rate r_t^n, depressing consumption. With lower inertia, our model delivers a larger nominal adjustment, keeping r_t^e closer to (or below) r_t^n and yielding the standard positive impact on consumption.

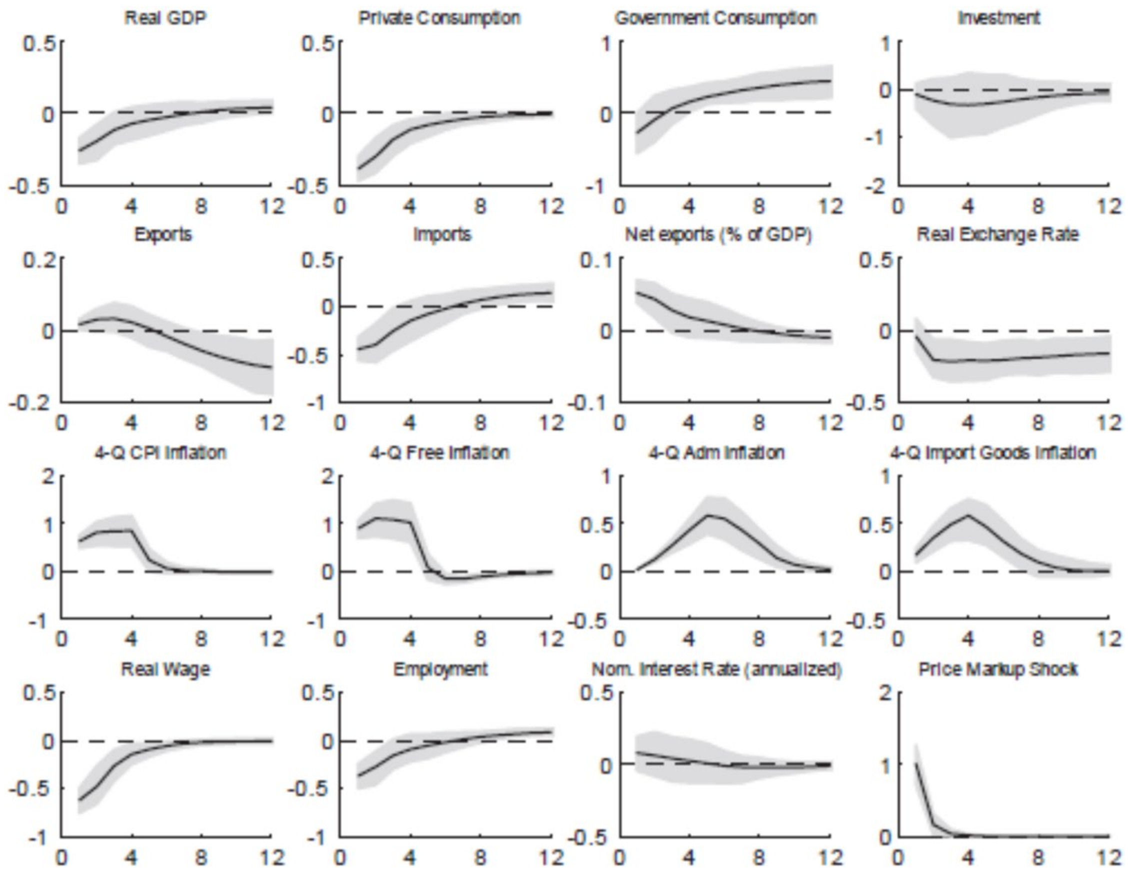

Fig. 3 IRF of the price markup shock in the SAMBA model. Source: Castro et al. (2015)

2. *CPI block.* SAMBA includes a distinct administered-price subindex with its own dynamics (posterior means $u_A^{(1)} \approx 0.05$, $u_A^{(2)} \approx 0.20$), which amplifies the disinflationary effect of a technology shock. By contrast, our CPI aggregates only domestic and imported consumption prices, with no administered-price component. This extra disinflation channel in SAMBA further raises r_t^e on impact for a given nominal-rate adjustment.

3. *Fiscal block.* In SAMBA, government purchases respond procyclically to productivity shocks and absorb resources, dampening private absorption, and wages are determined by an aggregate Calvo mechanism. In our SNA-compliant model, government spending is instead modeled as an input into the production of public services, while public wages are set administratively with inertia. These features weaken the crowding-out of private absorption on impact.

Finally, the treatment of private investment also contributes to the divergence. In our framework, the production of domestic inputs uses not only private but also public capital. This shared input structure mitigates the crowding-out effect on private investment, producing a smoother adjustment relative to SAMBA.

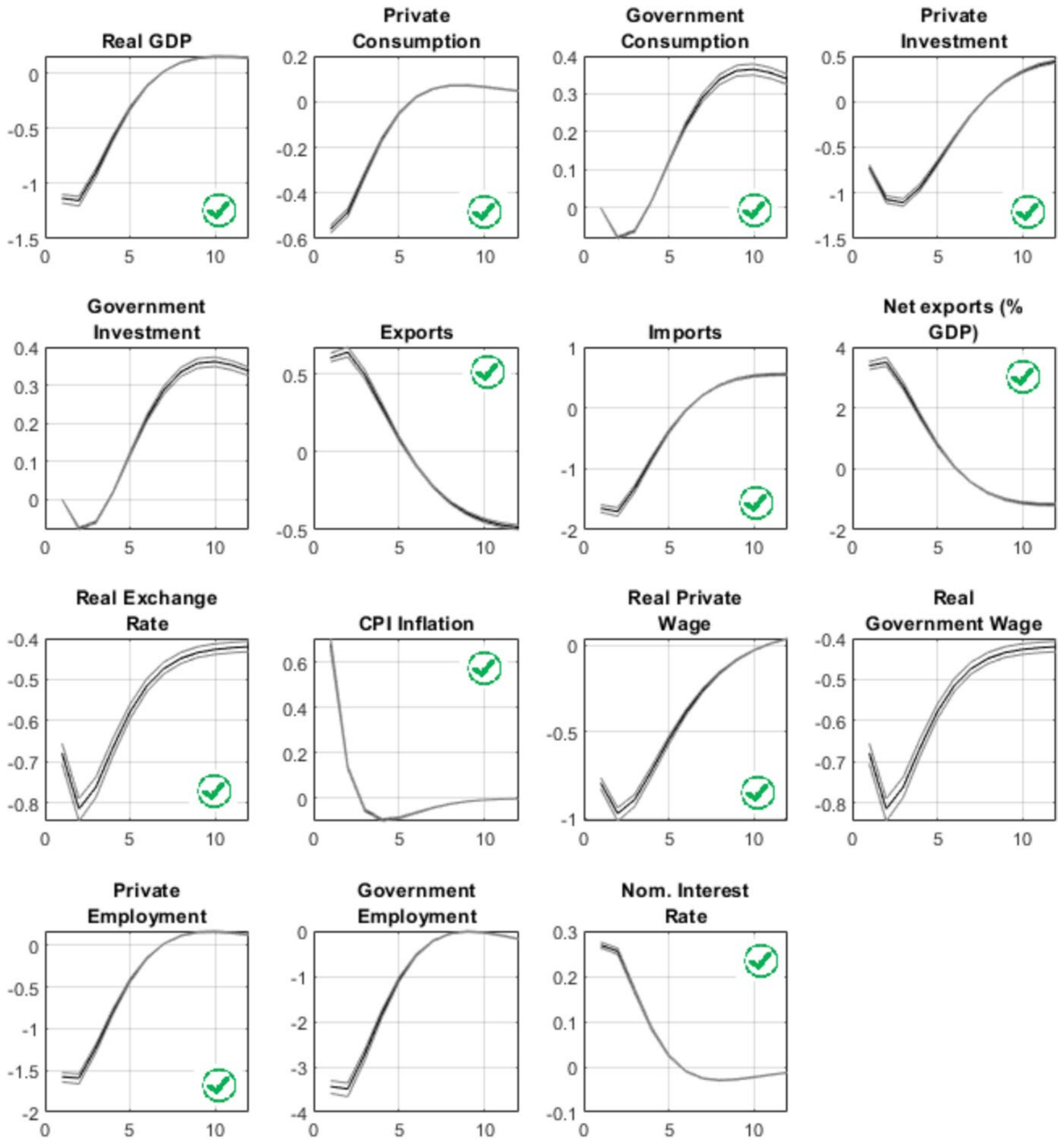

Fig. 4 IRF of the price markup shock in the SNA-compliant model. Source: Authors' elaboration

4.2 Price Markup Shock (Supply Shock)

The second supply-side shock is a price markup shock–an increase in firms' market power–with an initial shock of 1% in both models (Figs. 3 and 4). This shock essentially has the opposite effect to that of a productivity shock in the cost channel, as it directly impacts the Phillips curve, leading to an increase in the inflation rate. Given the higher cost of producing intermediate goods, there is a decrease in the production of these goods, which in turn lowers the value of demand variables. Additionally, according to the Taylor rule, the interest rate increases to stabilize the price level. Regarding the compatibility between the models, the result was quite satisfactory, with the only differing variable being private investment. The explanation for this result is similar to that given for this variable in the previous exercise (but in the opposite direction).

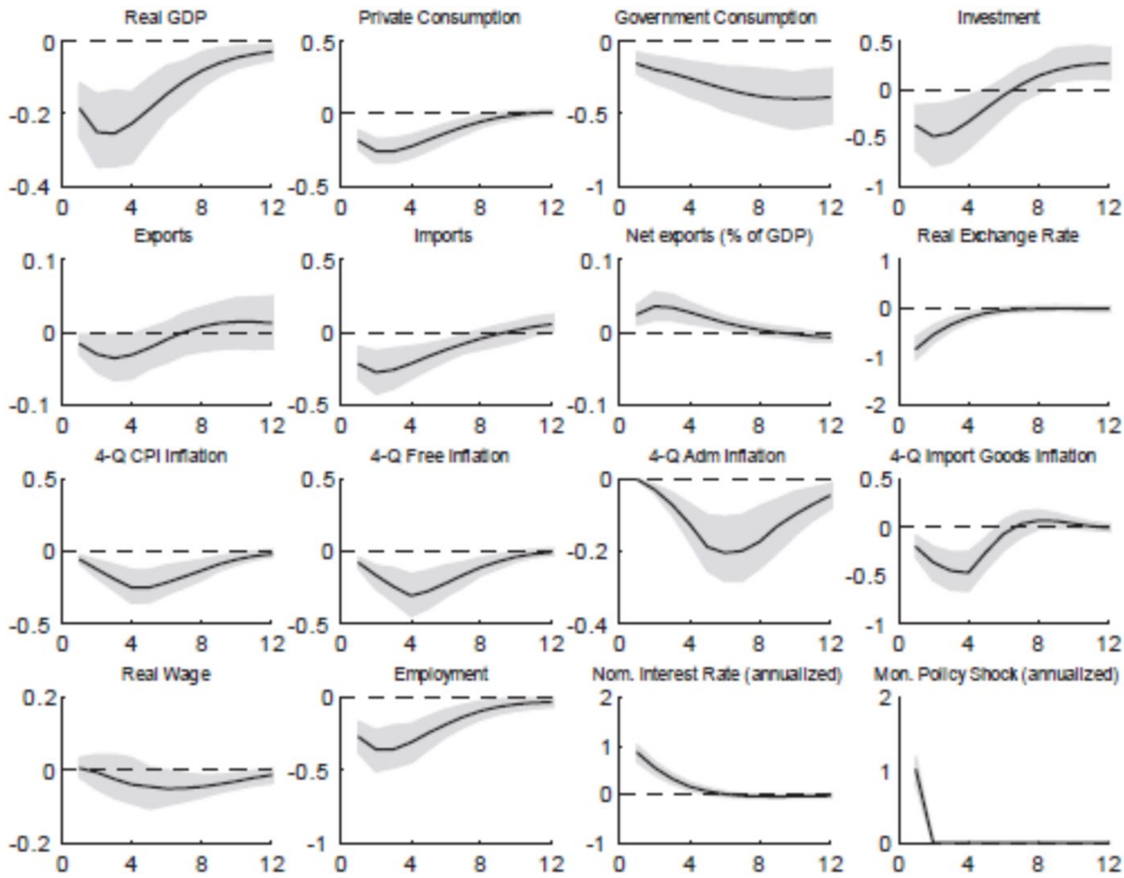

Fig. 5 IRF of the monetary shock in the SAMBA model. Source: Castro et al. (2015)

4.3 Monetary Shock

The analysis now shifts to the demand side. The first shock to be examined is a contractionary monetary shock of 1 percentage point in the annual interest rate (0,25 percentage points in the quarterly rate) in both models (Figs. 5 and 6). In this scenario, the main transmission channel is the intertemporal choice of Ricardian households; as the interest rate increases, the cost of present consumption rises. The model results are similar, except for the real exchange rate and exports. The explanation lies in the decrease in economic activity, which reduces imports (since households are consuming less and firms are using fewer inputs), and the surplus production is exported, explaining the rise in exports in the SNA-compliant model. Additionally, the higher interest rate attracts foreign capital. Coupled with the increase in exports (both goods and inputs), the nominal exchange rate appreciates. However, the drop in the price level is sufficient to depreciate the real exchange rate.

4.4 Preference Shock (Demand Shock)

The second demand-side shock is a preference shock, meaning that households change their intertemporal preference for consumption. In this exercise, there is a 1% decrease in the preference for present consumption in both models (Figs. 7 and 8). Similar to the monetary shock, the preference shock propagates its effects through the intertemporal choice of Ricardian households. However, unlike the monetary shock,

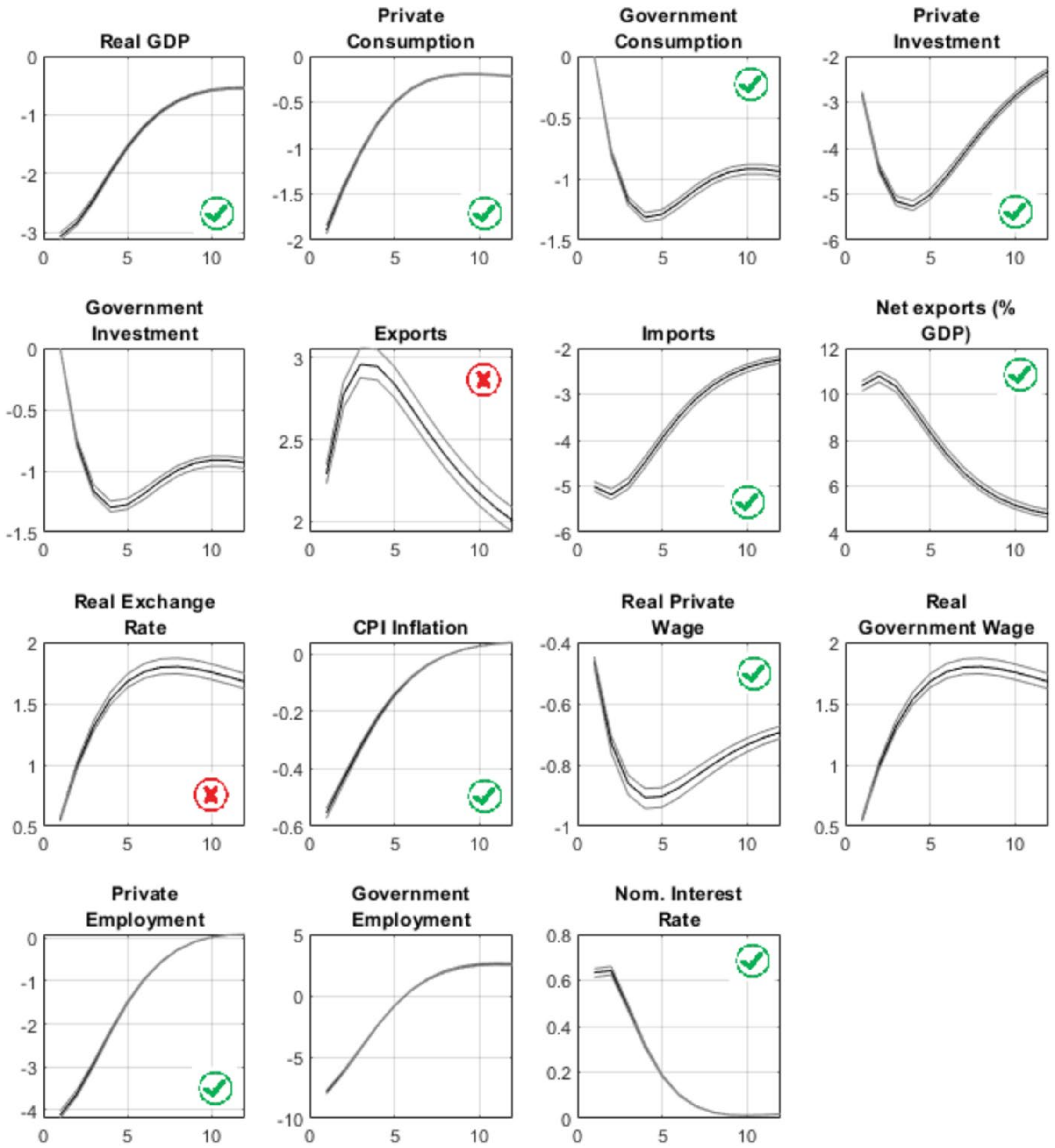

Fig. 6 IRF of the monetary shock in the SNA-compliant model. Source: Authors' elaboration

here, households shift from consumption to savings (as there is no evident income effect), resulting in a positive response in private investment. Concerning the compatibility between the models, all variables exhibited similar behavior, even for the two variables that diverged in the previous exercise: exports and the real exchange rate.

In summary, the compatibility exercise met expectations, indicating that the SNA-compliant model exhibited behavior consistent with the SAMBA model in equivalent scenarios.

4.5 Fiscal Shocks

According to Cavalcanti and Santos (2021), an administrative reform that reduces the public-private wage premium from 19% to 15% and aligns the retirement conditions

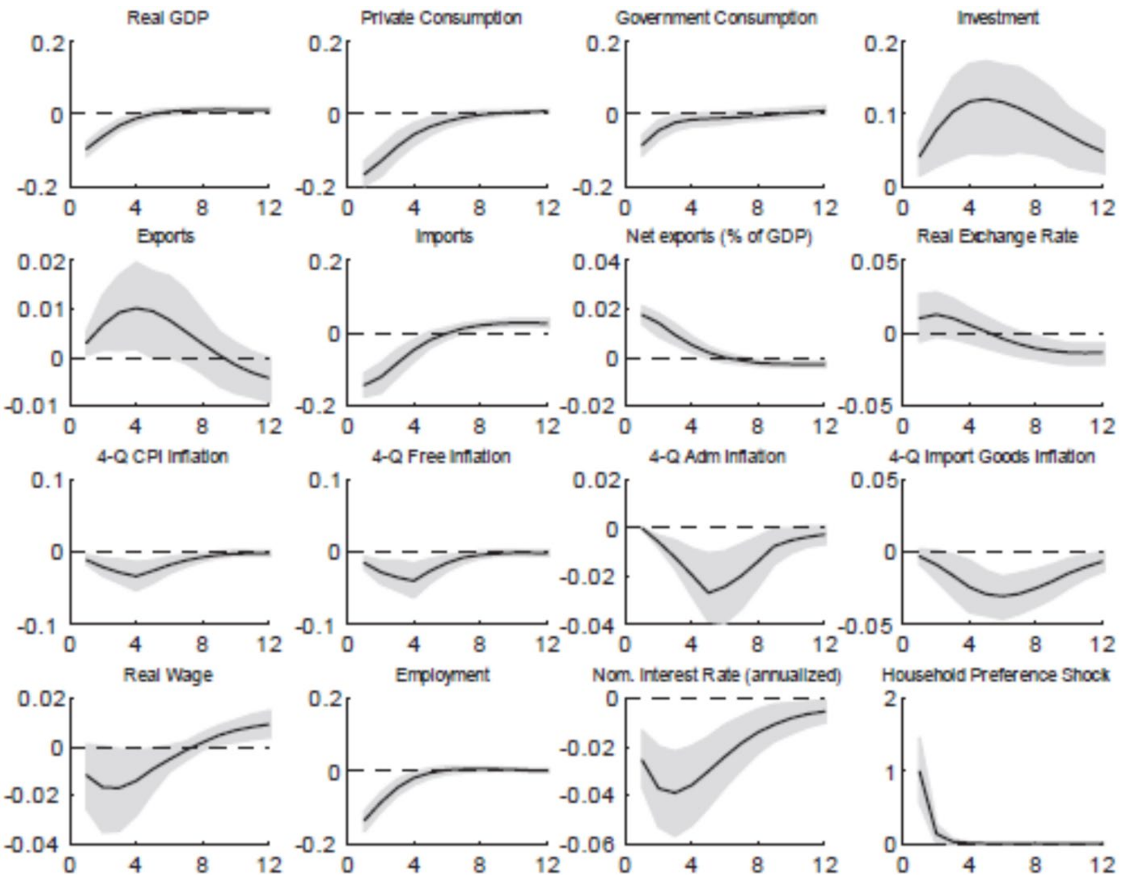

Fig. 7 IRF of the preference shock in the SAMBA model. Source: Castro et al. (2015)

of public sector workers with those of private sector workers could increase aggregate production by 11.2% in the long run. Even considering only the reduction of the wage premium, long-term output would increase by 4.65%. Figure 9 illustrates the shock of a reduction in public wages by the proportion suggested by Cavalcanti and Santos (2021), i.e., a reduction of $3.4\% = (1.15/1.19 - 1) \times 100$.

The reduction in public wages shows positive results; output continuously rises, reaching 0.3% by the 6th quarter, consistent with the results obtained by Cavalcanti and Santos (2021). Additionally, there is a reduction in resource misallocation as public sector labor is substituted with private sector labor. On the fiscal side, despite the decrease in revenue due to a smaller public workforce, public debt as a proportion of GDP decreases by approximately 2% in the 4th period, with this effect showing some persistence. This improvement in public debt sustainability allows for an increase in public investment spending, reaching 1% in the sixth period post-shock, which acts as a productivity gain in domestic input production within the model, thus increasing output. Finally, the decrease in public sector employment "forces" a shift in the composition of public service production, increasing current spending on goods and services to compensate for the reduction in other inputs, which may represent a gain in flexibility by potentially working with service provision contracts instead of relying on public servants, also related to reduced resource misallocation.

To interpret these dynamics, recall that the public wage is administered according to the rule described in Subsection 3.3.1, which allows for inertia, fiscal feedback, and a steady-state public-private premium. A negative innovation to this rule lowers

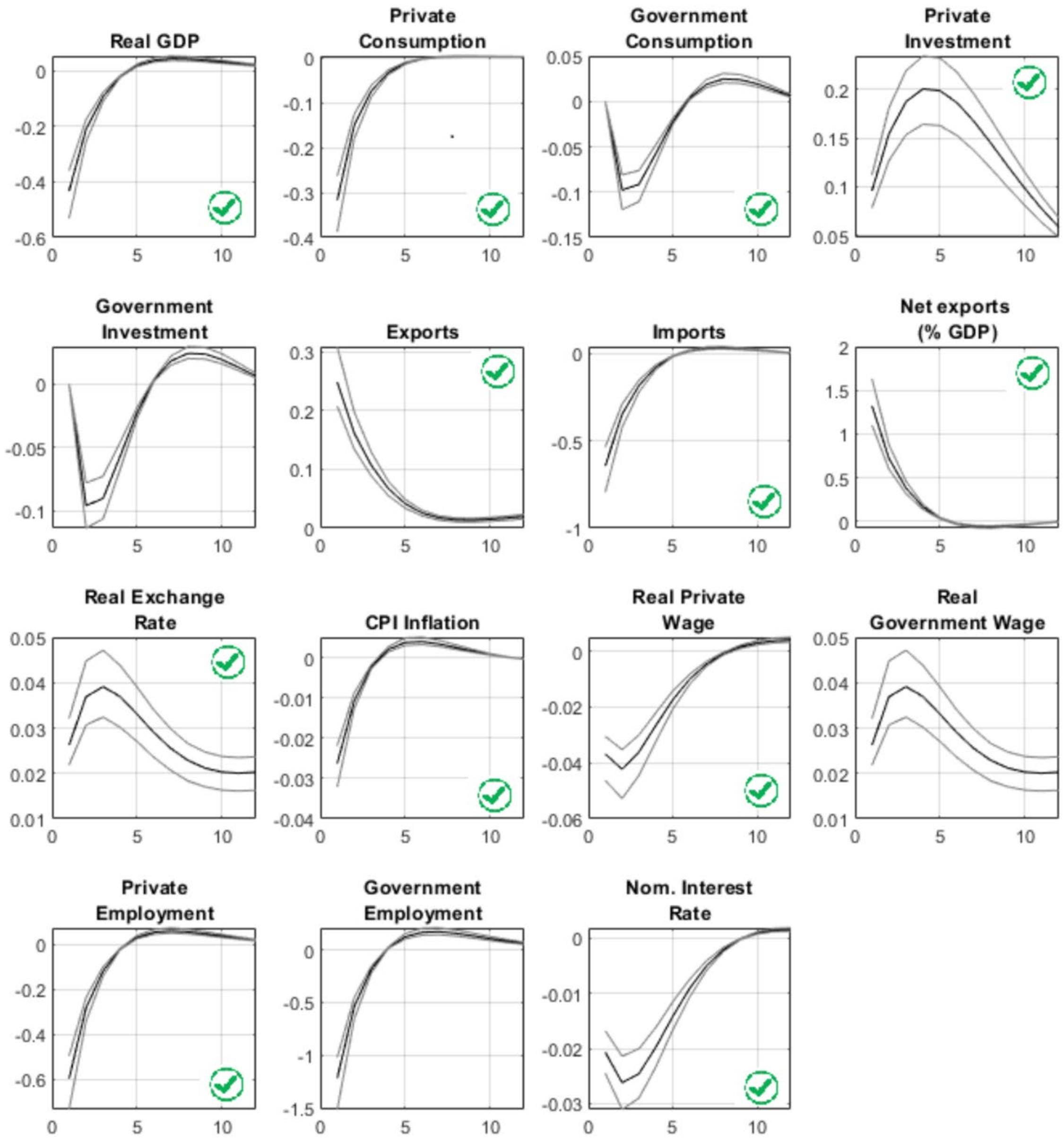

Fig. 8 IRF of the preference shock in the SNA-compliant model. Source: Authors' elaboration

w_t^G on impact, widens the wage gap, and reallocates labor from the public to the private sector. This outward shift in private labor supply puts downward pressure on the real private wage, ensuring that both wages co-move in the short run. The effect is transitory and weakens as private wages reoptimize and the MRS adjusts. Overall, the cut in administered public pay eases fiscal pressure and crowding-out, so that output improves despite the initial decline in public employment.

In the context of the shock to government consumption of goods and services (Fig. 10), it is important to remember that this consumption functions as an input in the production of public services within the model. With this in mind, the first significant result —consistent with the macroeconomic literature— is the crowding-in effect; a 0,15% reduction in government consumption increases private investment by up to 0,025% in the fifth period. Regarding output, the initial effect is a reduction of 0,02%, which returns to the steady state by the seventh period. This result is in line with the literature on fiscal multipliers, indicating a multiplier effect of less than 1.

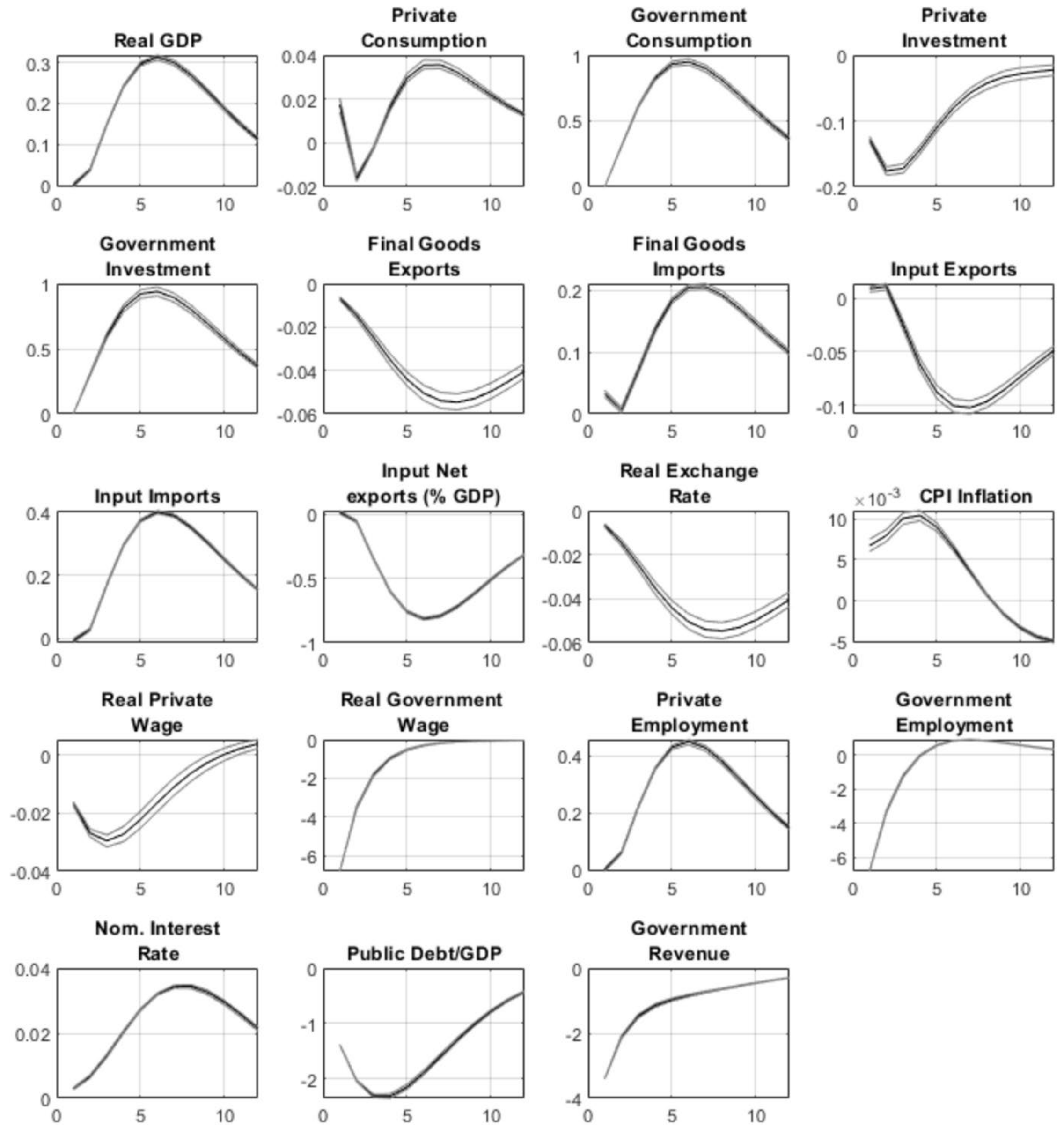

Fig. 9 Shock to public wages. Source: Author's elaboration

The other fiscal spending shock analyzed in this subsection is a decrease of one standard deviation in public investment (Fig. 11). The initial output drops by 0,03%, but this effect is persistent, representing a negative aspect of this shock. Furthermore, the crowding-in effect observed in the government consumption shock does not appear in this scenario. On the fiscal side, revenue follows the output trend, and this decline in revenue initially hampers public debt sustainability, although with the abatement of these effects, the public debt-to-GDP ratio begins to decrease from the third period onward.

Moving on to the analysis of taxes, an increase of one standard deviation in the consumption tax rate (Fig. 12) initially affects output negatively by 0,02%, with the effect persisting for six periods. This result is primarily due to the decline in the consumption of goods and private investment. This weaker economic activity also reduces the demand for labor. On the fiscal side, the public debt-to-GDP ratio ini-

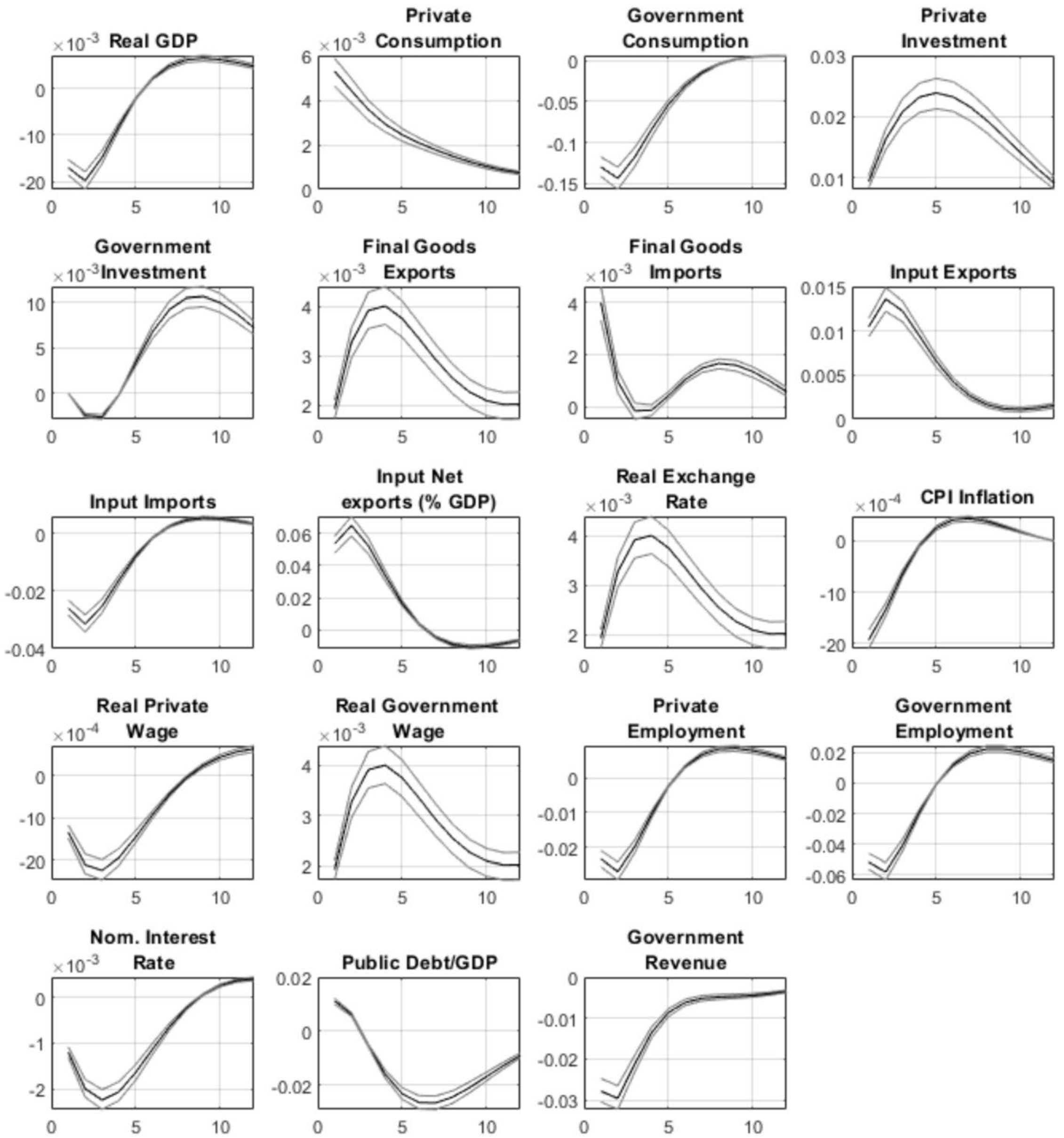

Fig. 10 Shock to government consumption. Source: Author's elaboration

tially increases slightly —given the weak economic activity— but improves with economic recovery.

The tax on imported goods has a similar "foundation" to the previous tax but is directed at imported goods (Fig. 13). An increase of one percentage point in this tax rate yields mild economic results, such as a 0,002% reduction in output, with a quick return to the steady state. It is noteworthy that the weak performance of this fiscal instrument is due to the small proportion of imported goods in the household consumption basket.

Another form of taxation in the model relates to income. First, we examine the effects of a one percentage point shock to the labor income tax rate (Fig. 14). This tax rate increase reduces the labor supply by 0,08% and 0,2% in the private and public sectors, respectively. This lower willingness to work initially negatively impacts output by 0,06%. On the fiscal side, there is a substitution of public labor for the

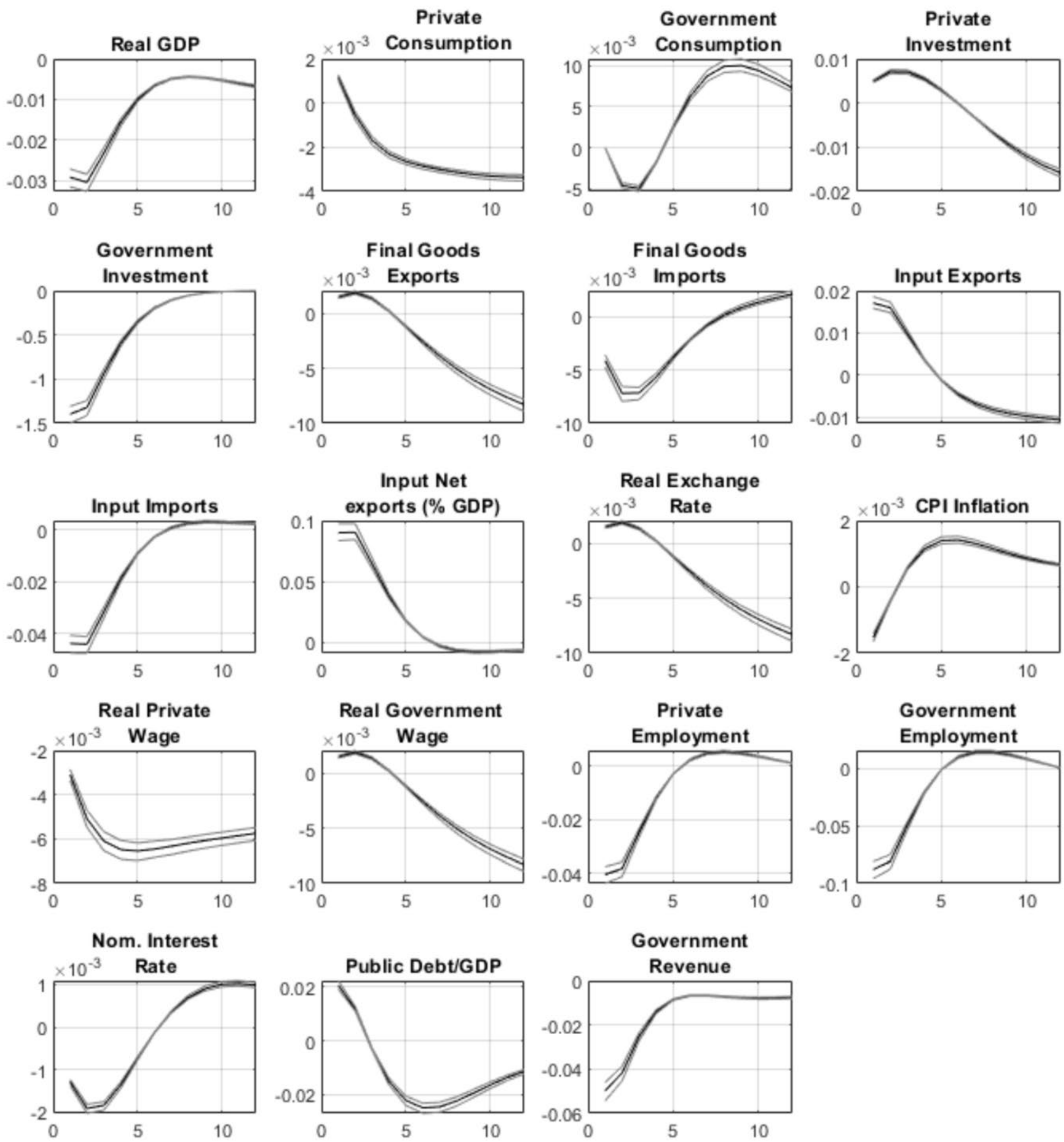

Fig. 11 Shock to government investment. Source: Author's elaboration

government's acquisition of goods and services. Tax revenue increases by 0,4%, but the highlight is the sustained decrease in the public debt-to-GDP ratio.

Similar to the previous shock, the one percentage point increase in the capital income tax rate (Fig. 15) affects the availability of resources used in the production of domestic inputs. Consequently, there is a persistent decline in private investment, initially negatively impacting output. Additionally, as with the previous shock, the highlight is the sustained decrease in the public debt-to-GDP ratio.

In the model, there are two contributions related to labor, one paid by households[17] and the other paid by firms. An increase of one percentage point in the firms' labor contribution rate (Fig. 16) presents moderate results for the economy, with output initially decreasing by 0,018%. The improvement in revenue by 0,02% facilitates a reduction in the public debt-to-GDP ratio, reaching -0,04% by the sixth period. Fur-

[17] As this result is very similar to the shock given to the labor income tax rate, it will not be presented here.

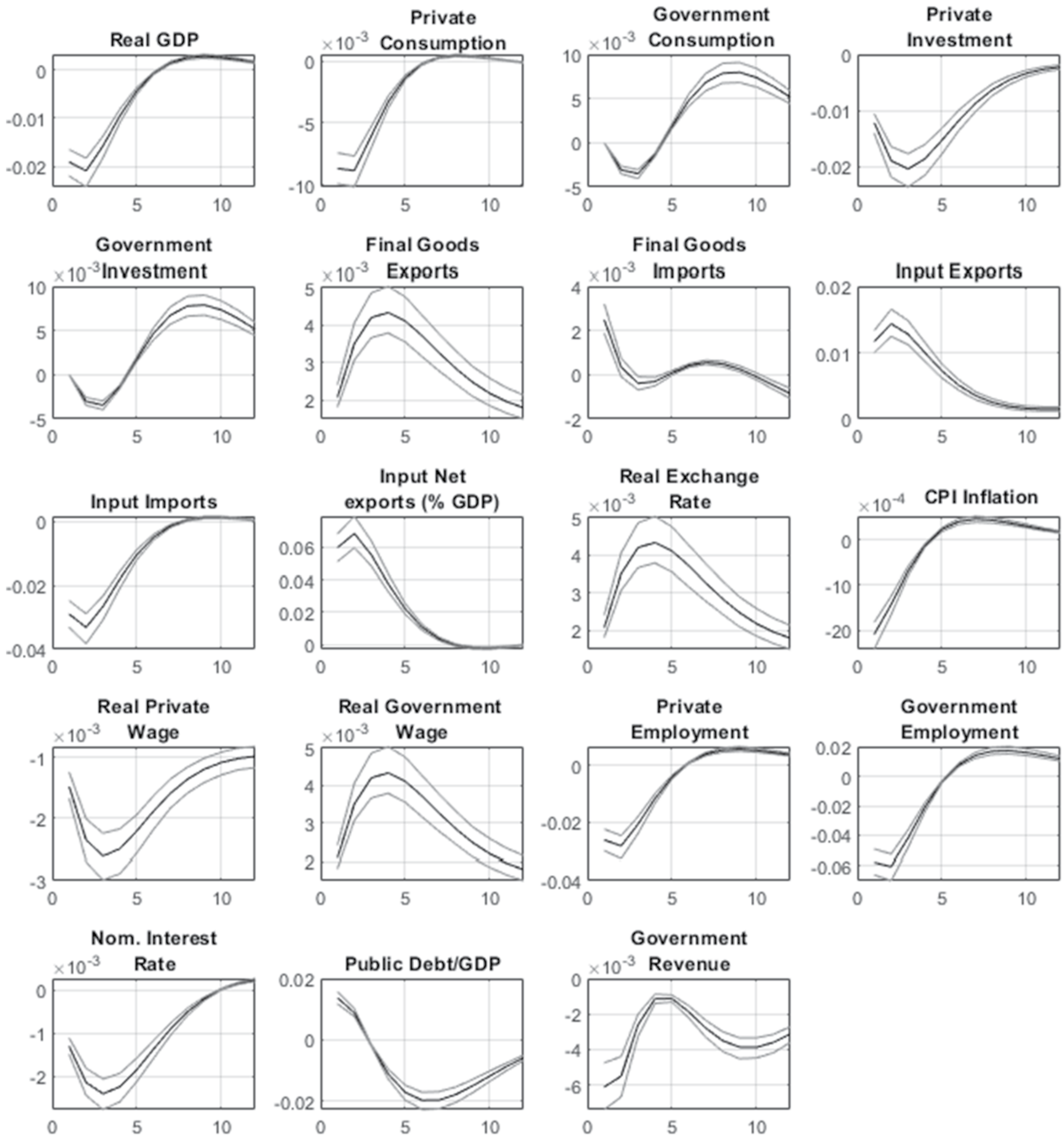

Fig. 12 Shock to the consumption tax. Source: Author's elaboration

thermore, the higher revenue allows for increases in public investment and government consumption by up to 0,02% and 0,01%, respectively.

4.6 Decomposition of Shocks to GDP

Figure 17 illustrates the decomposition of shocks to Brazil's observable GDP. The black line represents real Gross Domestic Product (GDP) growth, while the colored bars denote different types of economic shocks modeled to influence this growth. Each color corresponds to a distinct type of shock, such as supply shocks, demand shocks, fiscal policy shocks, monetary policy shocks, among others.

From 2002 to 2008, Brazil experienced robust economic growth, as evidenced by the rising black line. This growth can be attributed to a combination of positive

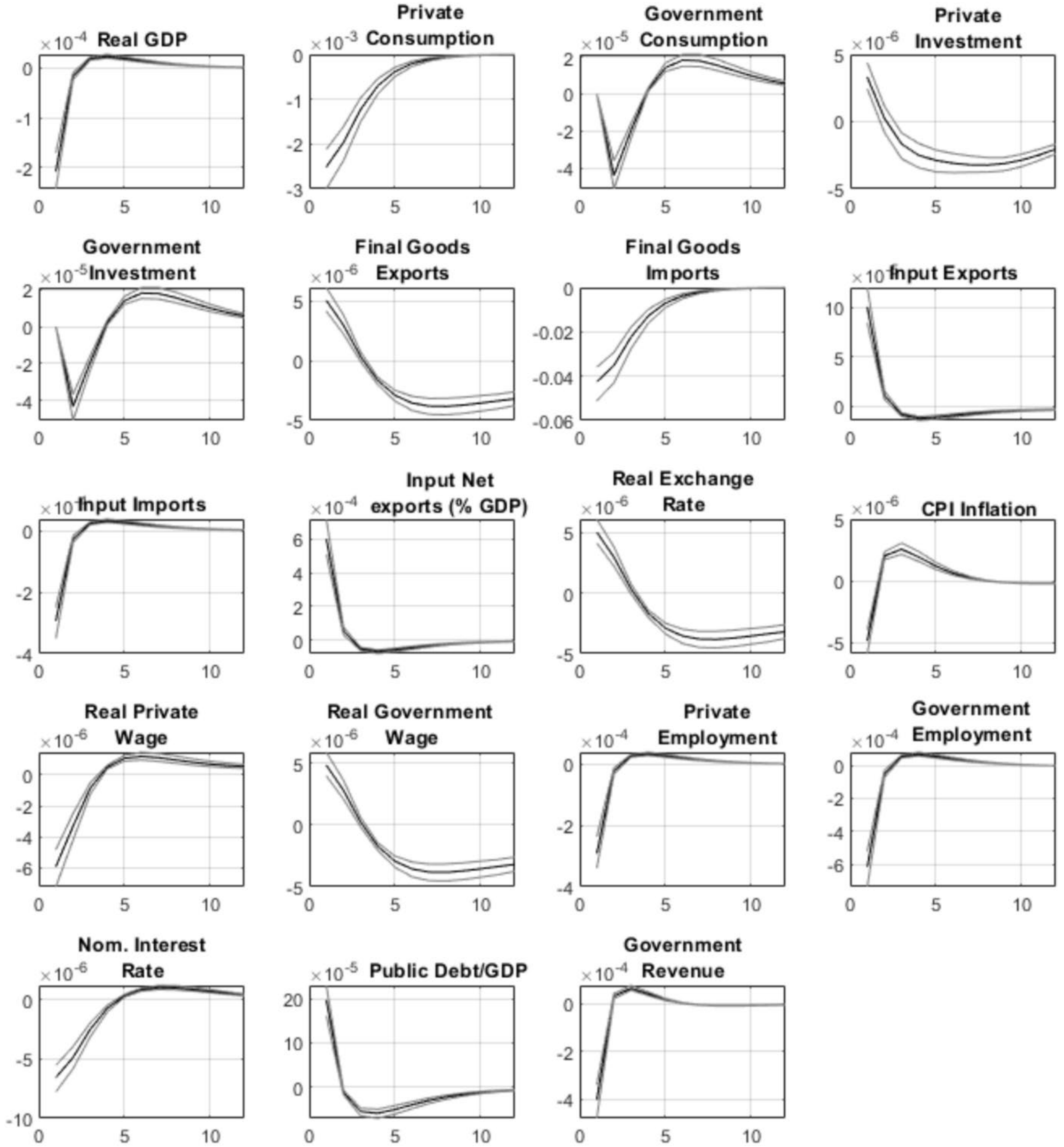

Fig. 13 Shock to the tax on imported goods. Source: Author's elaboration

shocks, including rising commodity prices and strong domestic demand (Cavalcanti et al. 2015), along with expansionary fiscal and monetary policies (Carvalho and Garcia 2008). The global financial crisis (2008-2009) had a significant negative impact on Brazilian economic growth. The shock decomposition shows a decline in demand for Brazilian exports, negatively affecting the economy. Literature highlights that emerging economies are particularly vulnerable to external shocks due to their reliance on exports (De Gregorio 2013). The global crisis also resulted in reduced investor confidence and credit constraints, exacerbating the economic slowdown (Didier et al. 2012).

Subsequently, there was a period of recovery and stagnation until 2014. The shock decomposition suggests that expansionary fiscal policies, such as increased public

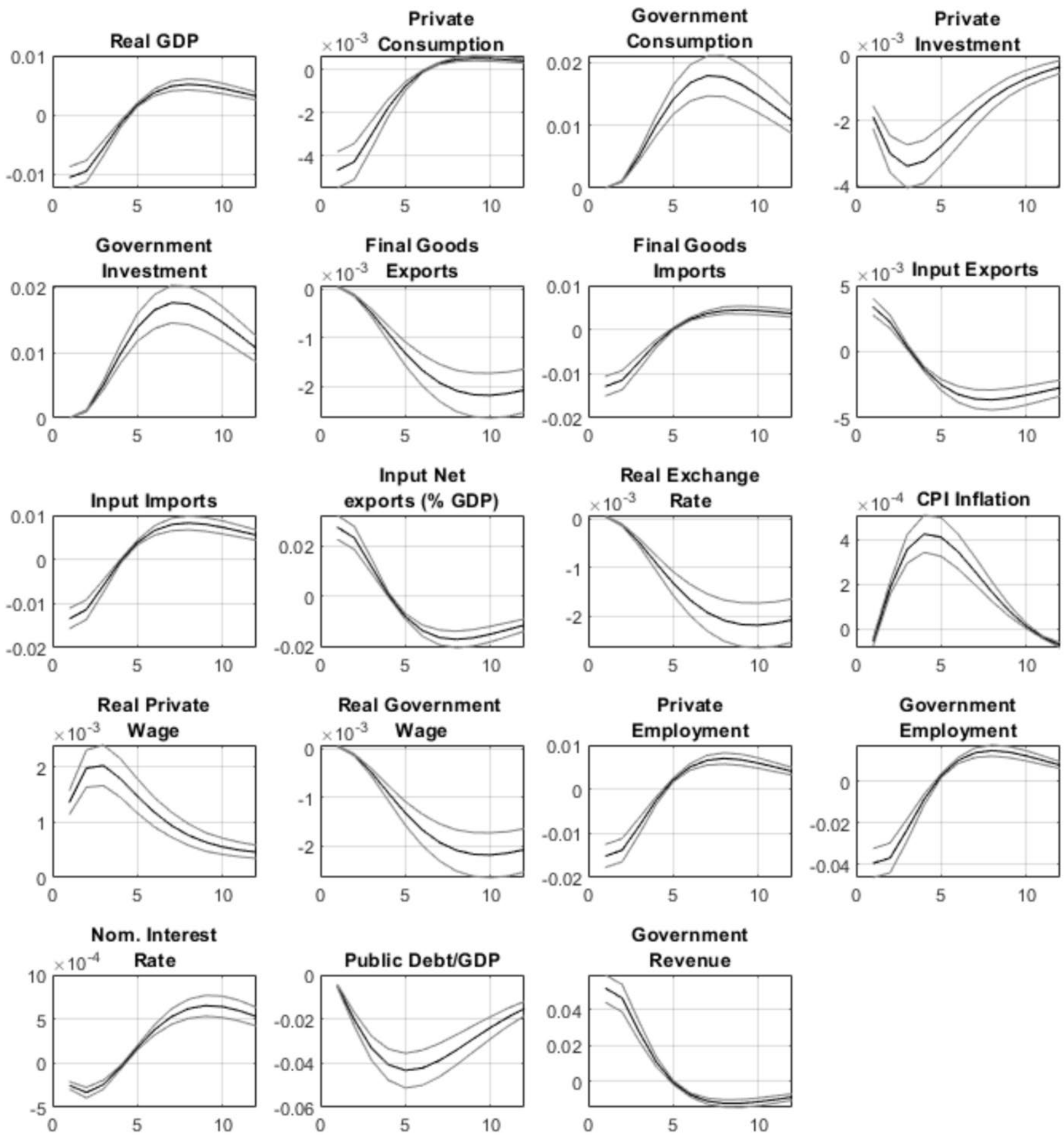

Fig. 14 Shock to the labor income tax. Source: Author's elaboration

spending, initially aided recovery. However, as discussed by Carvalho and Garcia (2008), the sustainability of these policies became a growing concern, leading to rising fiscal deficits and public debt. Furthermore, a series of adverse shocks, including energy sector issues and political crises, contributed to economic stagnation. These problems worsened from 2014 onwards. The political crisis, including corruption scandals and institutional uncertainty, had a devastating impact on economic confidence and investment (Almeida et al. 2017). In response to rising deficits, the government implemented more restrictive fiscal policies, which, combined with the political crisis, exacerbated the recession (Bastos 2017). From 2017, Brazil began showing signs of recovery. However, the pandemic brought significant negative shocks, such as reduced demand, supply chain disruptions, and increased unemployment, leading to a new recession (Bonacini et al. 2021).

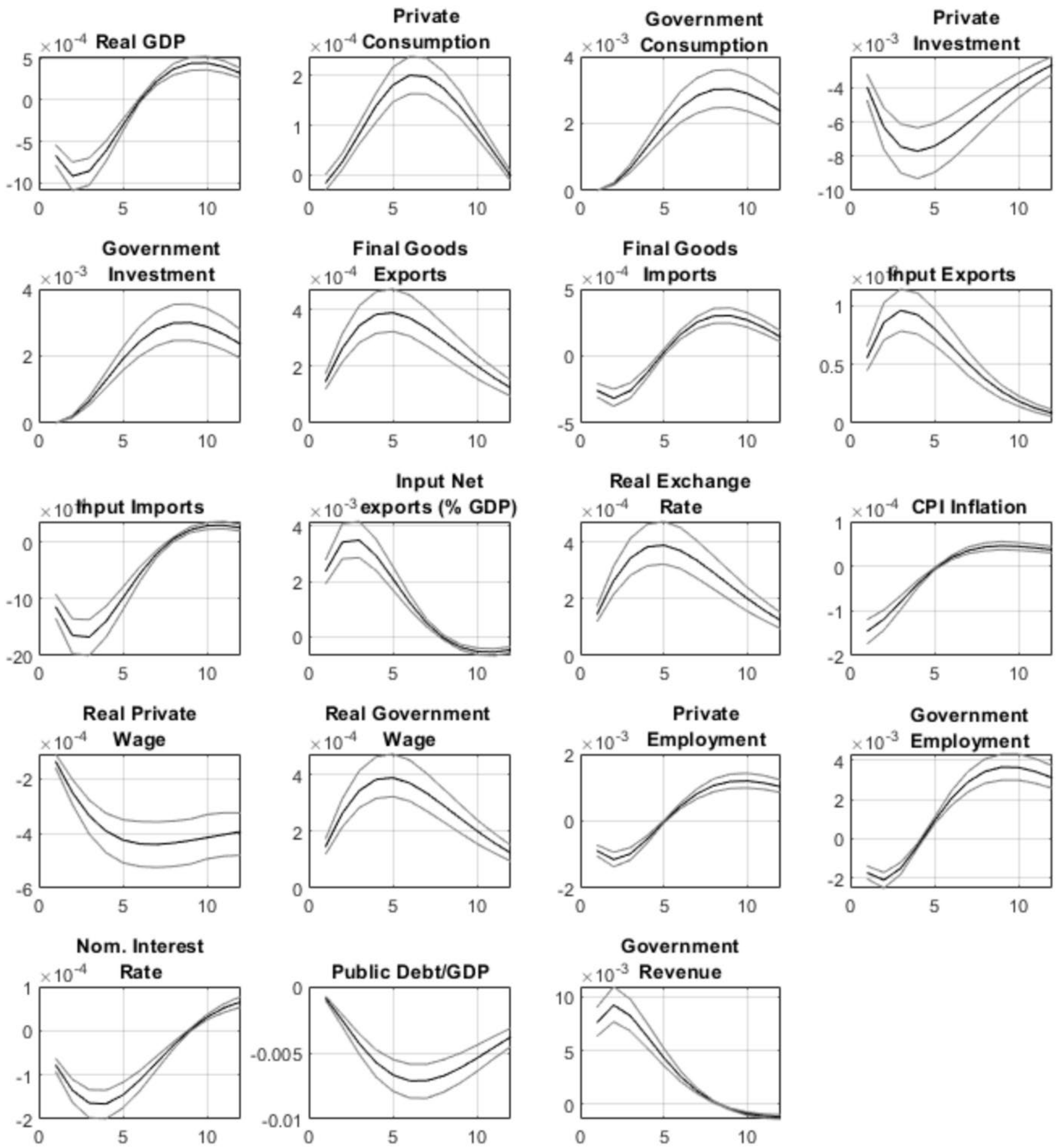

Fig. 15 Shock to the capital income tax. Source: Author's elaboration

5 Robustness: Stone–Geary Preferences for Non-Ricardian Households

Following Ravn et al. (2008)[18], we extend the baseline model by introducing Stone–Geary ("subsistence") preferences *only for non-Ricardian (NR) households*, leaving the Ricardian block and all nominal rigidities unchanged[19]. We keep external habit in

[18] While Ravn et al. (2008)'s analysis focuses on the cyclicality of markups and the effects of government spending shocks in a Real Business Model (RBC) model with monopolistic competition, our objective is to explore the implications of this specification within a small open economy TANK framework. Thus, the functional form is identical, although the scope and focus of our analysis differ.

[19] See, also, Geary (1950); Stone (1954); and Gollin et al. (2002).

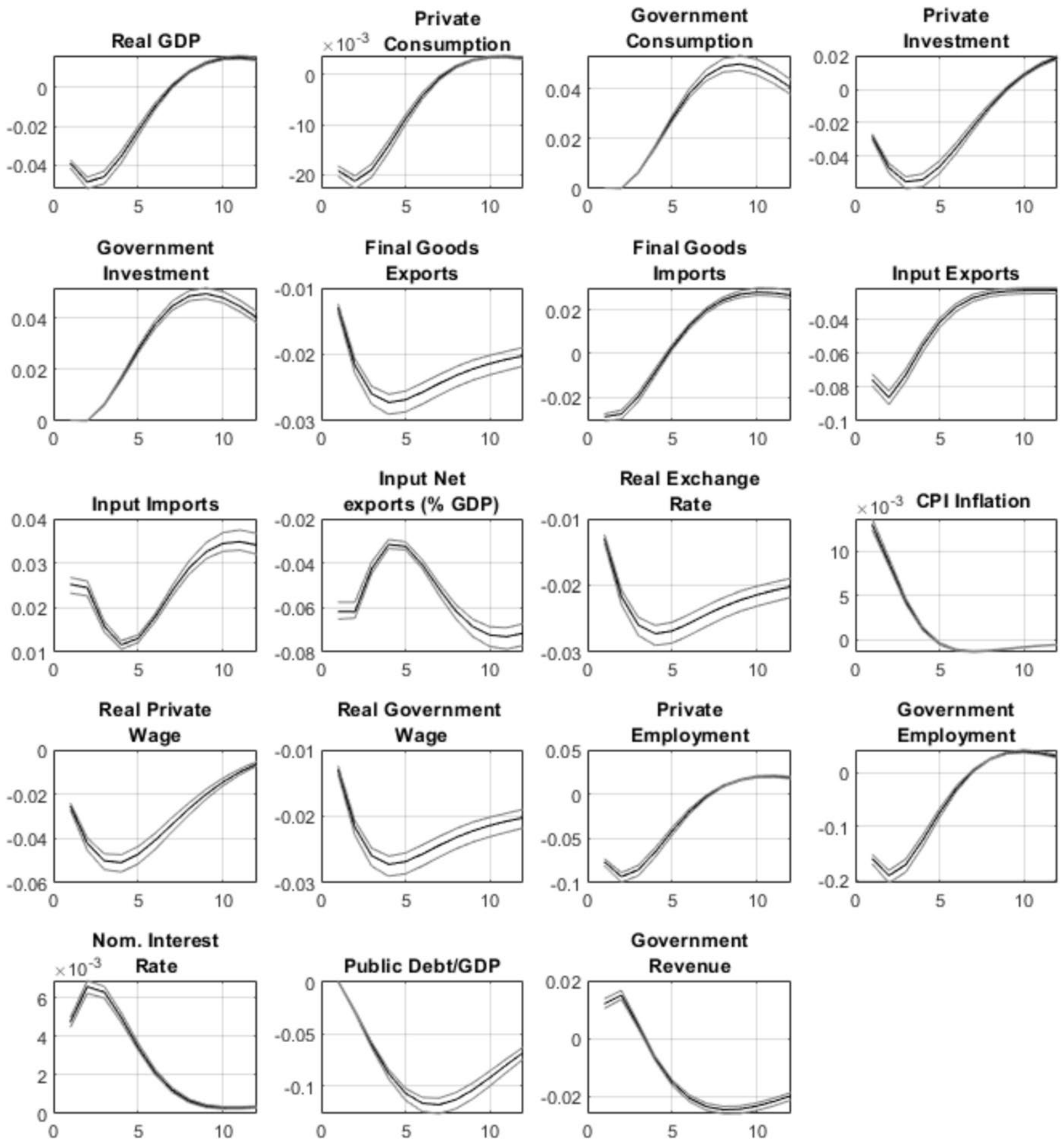

Fig. 16 Shock to firms' labor contribution. Source: Author's elaboration

NR consumption and place it inside the effective consumption aggregator that enters utility (so that habits and subsistence jointly shift the level of marginal utility, but not its slopes with respect to relative prices).

Specifically, we define a subsistence level

$$c_{NR}^{\text{sub}} \equiv \theta_{cNR} C_{ss}^{NR}, \qquad \theta_{cNR} \in [0, 1),$$

and the habit-adjusted NR consumption

$$\bar{C}_t^{NR} \equiv C_t^{NR} - \gamma_C C_{t-1}^{NR}.$$

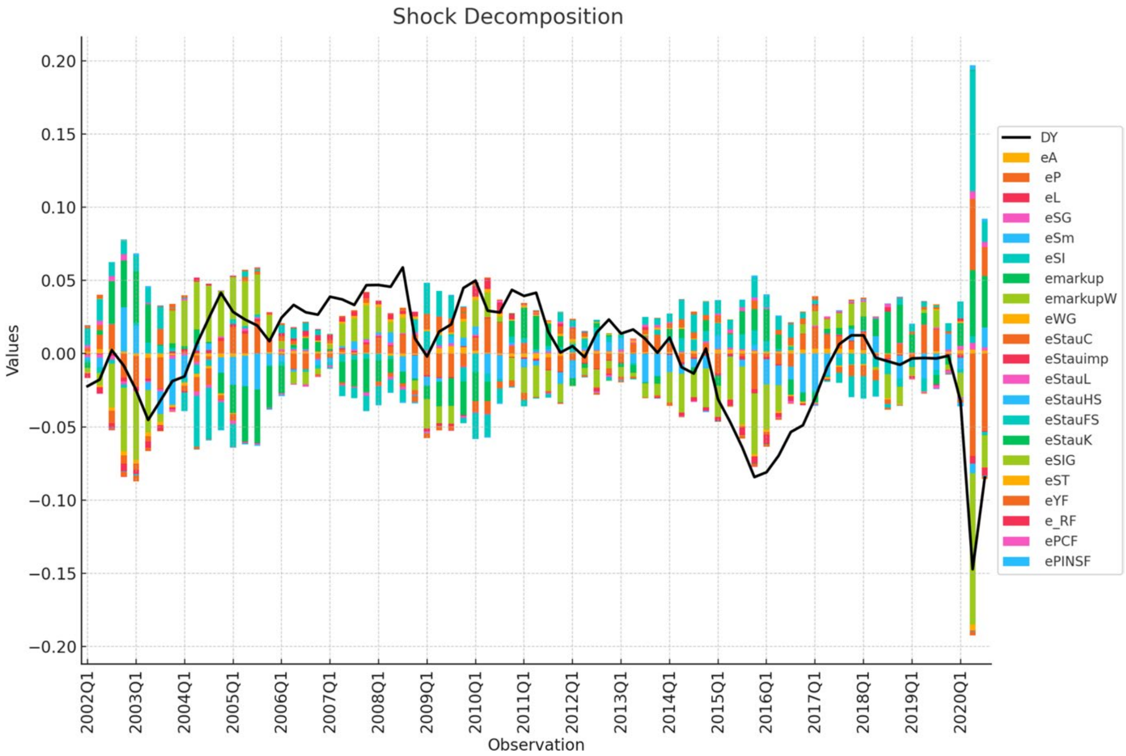

Fig. 17 Decomposition of shocks to observable GDP. Source: Authors' elaboration

The effective NR consumption that enters utility is then

$$X_t^{NR} \;\equiv\; \bar{C}_t^{NR} - c_{NR}^{\text{sub}} + \gamma_{servG}\, Serv_t^{G}. \tag{70}$$

NR period utility becomes

$$U_t^{NR} \;=\; \frac{\left(X_t^{NR}\right)^{1-\sigma}}{1-\sigma} \;-\; S_t^L\,\frac{\left(L_t^{NR,P}\right)^{1+\varphi_P}}{1+\varphi_P}.$$

Evaluating at the steady state,

$$\bar{C}_{ss}^{NR} = (1-\gamma_C)C_{ss}^{NR}, \qquad X_{ss}^{NR} = (1-\gamma_C-\theta_{cNR})\,C_{ss}^{NR} + \gamma_{servG}\,Serv_{ss}^{G} \;>\; 0.$$

Log-linearizing around the steady state (hats denote log-deviations) yields

$$\widehat{X}_t^{NR} = \theta_C^{NR}\,\widehat{C}_t^{NR} + \theta_S^{NR}\,\widehat{Serv}_t^{G}, \tag{71a}$$

$$\theta_C^{NR} \equiv \frac{\bar{C}_{ss}^{NR}}{X_{ss}^{NR}} = \frac{(1-\gamma_C)\,C_{ss}^{NR}}{(1-\gamma_C-\theta_{cNR})\,C_{ss}^{NR} + \gamma_{servG}\,Serv_{ss}^{G}}, \tag{71b}$$

$$\theta_S^{NR} \equiv \frac{\gamma_{servG}\, Serv_{ss}^G}{X_{ss}^{NR}}\,. \tag{71c}$$

In the linear model, this shows up by modifying the NR shadow value as

$$\widehat{\Lambda}_t^{NR} = \widehat{\Lambda}_t^{NR,\text{baseline}} - \underbrace{\sigma\left(\theta_C^{NR}\,\widehat{C}_t^{NR} + \theta_S^{NR}\,\widehat{Serv}_t^{G}\right)}_{\text{Stone–Geary re-scaling}}, \tag{72}$$

where $\widehat{\Lambda}_t^{NR,\text{baseline}}$ collects the terms already present in the baseline (tax wedges, relative prices, and measurement blocks). The subtracted term corresponds to the *Stone–Geary re-scaling* of NR marginal utility around steady state.

All other NR optimality conditions (including the intratemporal composition between domestic and imported consumption) remain unchanged. Ricardian Euler equations and the price/wage Phillips curves are unaffected by construction.

We treat θ_{cNR} as an additional structural parameter with a Beta prior centered at 0.25 (s.d. 0.10). The posterior mean is $\hat{\theta}_{cNR} = 0.264$ with a 90% HPD interval [0.263, 0.266] (Table 1).

The Stone-Geary specification acts primarily as a steady-state re-scaling of non-Ricardian marginal utility, leaving relative-price conditions and intertemporal margins intact. Consistent with this, the simulated second moments and variance decompositions are nearly indistinguishable from the baseline without Stone–Geary preferences. Table 2 compares theoretical standard deviations from both estimated models: output, consumption, and investment move by about 2-3% at most (e.g., σ_Y falls from 16.51 to 16.13, σ_C from 8.97 to 8.84, σ_{IP} from 31.05 to 29.96). Similar small percentage changes obtain for wages and employment; correlation matrices remain virtually unchanged.

Variance decompositions (Table 3) confirm the same message: the dominant shocks and their relative contributions are stable. For example, the share of the import-conditions shock e_{Sm} in output variance changes by less than 0.2 percentage points (from 88.82% to 88.98%); contributions of markup and wage-markup shocks move by under 0.1 percentage points. Table 4 likewise shows that the estimated public wage inertia barely changes across specificacions. These all differences are immaterial for our transmission mechanisms and policy implications. Introducing Stone–Geary preferences for non-Ricardian households leaves the fit, impulse responses, and key parameter estimates essentially unchanged. The extension does not alter the qualitative mechanisms nor our policy conclusions; it simply re-scales non-Ricardian marginal utility around steady state. Thus, Stone-Geary preferences enhance empirical realism while preserving the model's transmission channels and policy insights (Table 5).

Table 1 Parameters: Posterior Means and 90% HPD Intervals

Parameter	Prior	Post. mean	HPD 5%	HPD 95%
χ_{BF}	18.500	19.2947	19.2619	19.3303
θ_W	0.850	0.8576	0.8573	0.8579
var ψ	1.105	1.1169	1.1163	1.1174
γ_C	0.800	0.7826	0.7822	0.7830
θ^c_{NR}	0.250	0.2643	0.2629	0.2655
χ	50.500	52.3806	52.0158	52.7080
$PINSF^{ss}$	1.050	0.9444	0.9415	0.9476
PCD^{ss}	1.100	1.0957	1.0943	1.0970
PCF^{ss}	1.050	0.8469	0.8388	0.8566
γ_R	0.800	0.7843	0.7836	0.7850
γ_π	2.500	2.6105	2.6079	2.6136
γ_Y	0.115	0.1119	0.1116	0.1122
ω_R	0.650	0.6466	0.6461	0.6470
γ_G	0.130	0.1574	0.1561	0.1587
α_G	0.200	0.2054	0.2051	0.2056
τ^{ss}_{FS}	0.080	0.0802	0.0801	0.0802
τ^{ss}_{imp}	0.250	0.2490	0.2483	0.2498
γ_{WG}	0.500	0.5064	0.5045	0.5081
$\gamma_{\tau C}$	0.500	0.4703	0.4679	0.4732
$\phi_{\tau C}$	0.750	0.7131	0.7120	0.7146
$\gamma_{\tau imp}$	0.500	0.3956	0.3917	0.3997
$\phi_{\tau imp}$	0.500	0.4746	0.4721	0.4772
$\gamma_{\tau L}$	0.500	0.4605	0.4545	0.4653
$\phi_{\tau L}$	0.750	0.7375	0.7356	0.7395
$\gamma_{\tau HS}$	0.500	0.6415	0.6374	0.6468
$\phi_{\tau HS}$	0.500	0.5248	0.5185	0.5309
$\gamma_{\tau FS}$	0.500	0.5270	0.5229	0.5302
$\phi_{\tau FS}$	0.500	0.5675	0.5643	0.5713
$\gamma_{\tau K}$	0.725	0.7305	0.7303	0.7307
$\phi_{\tau K}$	0.325	0.3278	0.3277	0.3280
γ_T	0.500	0.5504	0.5488	0.5533
ϕ_T	0.750	0.7777	0.7739	0.7810
γ_{IG}	0.500	0.5337	0.5305	0.5360
ϕ_{IG}	-0.500	-0.4632	-0.4657	-0.4603
γ_{GG}	0.500	0.3821	0.3769	0.3855
ϕ_{GG}	-0.500	-0.5344	-0.5400	-0.5297
ρ_A	0.500	0.5707	0.5697	0.5715
ρ_P	0.500	0.4701	0.4667	0.4734
ρ_{YF}	0.500	0.4915	0.4862	0.4956
ρ_{markup}	0.500	0.5749	0.5714	0.5793
ρ_{markupW}	0.500	0.4585	0.4561	0.4607

Note: Laplace log data density is -1564.69

Table 2 Robustness: Standard Deviations of Model-Implied Moments (*no SG* vs. *with SG*)

Variable	Std. no SG	Std. with SG	Δ% (SG vs. no SG)
Y	16.5120	16.1290	-2.32
C	8.9746	8.8355	-1.55
G	18.2022	17.6881	-2.82
IG	27.3441	26.5707	-2.83
IP	31.0468	29.9565	-3.51
S_{real}	31.0663	29.9838	-3.49
PICD	2.0970	2.0826	-0.69
WP_{real}	12.3636	12.0363	-2.65
WG_{real}	32.2903	31.2509	-3.22
LP	13.7028	13.4266	-2.02
LG	49.3416	48.0856	-2.55
RB	3.4651	3.4745	+0.27
ServG	36.6880	35.8027	-2.41
By	52.1479	50.6713	-2.83
taxes	22.3319	21.7885	-2.43
Mean absolute change: $\approx 2.23\%$. Max: -3.51% (IP)			

Note: Differences across models are small and mostly negative (slightly lower volatility) when introducing Stone-Geary. Computed from the linearized solution (population/theoretical moments); units are percent deviations unless noted

Table 3 Variance Decomposition (Y and C, %) – Selected Shocks

	Y		C	
Shock	No SG	With SG	No SG	With SG
e_{Sm}	88.82	88.98	92.10	92.25
e_{markup}	3.16	3.15	2.49	2.46
e_{markupW}	4.83	4.75	3.62	3.55
e_A	0.09	0.09	0.08	0.08
e_{SI}	1.26	1.24	0.69	0.66
e_{WG}	0.21	0.22	0.04	0.04
e_P	0.14	0.14	0.22	0.22
e_{PINSF}	0.16	0.16	0.15	0.16

Note: We display the largest and most policy-relevant shocks. Differences across specifications are ≤ 0.3 pp in all reported entries

Table 4 Public wage inertia γ_{WG} across specifications

	Stone-Geary (Non-Ricardian only)	No Stone-Geary
γ_{WG} (post. mean)	0.5064	0.5159
90% HPD interval	$[0.5045, 0.5081]$	$[0.5124, 0.5196]$

6 Concluding Remarks

This study presents a medium-scale DSGE model with an enhanced fiscal block that is fully consistent with the System of National Accounts (SNA). The framework integrates a detailed government structure and a wide set of fiscal instruments, which allows for a more precise and transparent evaluation of fiscal policy compared with conventional DSGE models.

Table 5 Shock Standard Deviations: Posterior Means and 90% HPD Intervals

Domestic and fiscal shocks				External and price-setting shocks			
Shock	Mean	HPD 5%	HPD 95%	Shock	Mean	HPD 5%	HPD 95%
e_A	1.1148	1.0742	1.1627	e_{YF}	0.9951	0.9806	1.0123
e_P	0.1231	0.1176	0.1302	e_{RF}	0.9829	0.9654	1.0020
e_L	0.7455	0.7177	0.7911	e_{PCF}	0.1247	0.1176	0.1315
e_{SG}	0.1255	0.1176	0.1350	e_{PINSF}	0.5940	0.5766	0.6069
e_{Sm}	0.1204	0.1176	0.1240	e_{ST}	1.4815	1.4431	1.5148
$e_{\tau C}$	0.1501	0.1341	0.1665	e_{SI}	0.9667	0.9437	0.9934
$e_{\tau imp}$	0.3156	0.2831	0.3614	e_{markup}	0.9743	0.9606	0.9889
$e_{\tau L}$	0.1895	0.1713	0.2100	e_{markupW}	0.1438	0.1323	0.1579
$e_{\tau HS}$	0.1900	0.1619	0.2143	$e_{\tau FS}$	1.2541	1.2292	1.2842
$e_{\tau K}$	0.1745	0.1572	0.1953	e_{Σ}	0.2888	0.2489	0.3421

In a comparative assessment with the Central Bank of Brazil's SAMBA model, our SNA-compliant DSGE replicates the behavior of key macroeconomic indicators under different shocks. Its fiscal architecture provides policymakers with richer insight into the consequences of fiscal reforms and targeted measures, making it a reliable analytical tool. Furthermore, the model can accommodate Brazil-specific fiscal scenarios—such as the administrative reform, a recurring headline in the Brazilian media—, which underscores its practical policy relevance.

We further test robustness by incorporating Stone-Geary (subsistence) preferences for non-Ricardian households. The findings are materially unaffected, reinforcing that our conclusions are not model-specification dependent.

Overall, the results highlight the importance of accounting for the complex interplay between fiscal policy, monetary rules, and external shocks in emerging economies. This research thus contributes a robust framework that is particularly well-suited to analyzing fiscal dynamics in contexts where institutional features and government accounts are critical.

Appendix A

6.1 Empirical Analysis

6.1.1 Data Processing

The dataset utilized in the model comprises quarterly data from the first quarter of 2002 to the third quarter of 2020, as detailed in Table 6. The data were processed to remove seasonal effects and trends using the X12-ARIMA algorithm and log differences, respectively. The global GDP series is composed of the GDPs of the USA, China, and the Eurozone, weighted according to their respective proportions.

Table 6 Observable variables in the model

Series	Source
GDP pm - real quarterly var. (%)	IBGE/SCN
Final consumption - households - real quarterly var. (%)	IBGE/SCN
Final consumption - APU - real quarterly var. (%)	IBGE/SCN
Gross fixed capital formation - real quarterly var. (%)	IBGE/SCN
Exports - goods and services - real quarterly var. (%)	IBGE/SCN
Imports - goods and services - real quarterly var. (%)	IBGE/SCN
Exchange rate - R$/US$	Bacen/Boletim/BP
Interest rate - Over/Selic (% p.m.)	Bacen/Boletim/M. Finan.
IPCA - general (% p.m.)	IBGE/SNIPC
CPI - USA (% p.q.)	FRED, Federal Reserve Bank of St. Louis
10-year bond yield - USA (% p.m.)	FRED, Federal Reserve Bank of St. Louis
GDP - USA - real quarterly var. (%)	FRED, Federal Reserve Bank of St. Louis
GDP - Eurozone - real quarterly var. (%)	FRED, Federal Reserve Bank of St. Louis
GDP - China - real quarterly var. (%)	FRED, Federal Reserve Bank of St. Louis
Industry hours worked (2006 = 100)	CNI
Cofins - gross revenue - R$ (millions)	Min. Fazenda/SRF
EMBI - Brazil risk	JP Morgan
Financial account - balance	BCB/BP
(Captures - Concessions) - US$ (millions)	–
Government personnel expenses	Fiscal Sub-secretariat/SPE/ME
Gross general government debt	Fiscal Sub-secretariat/SPE/ME
Commodity index (IC-BR)	DEPEC/BCB
τ^{C}	Fiscal Sub-secretariat/SPE/ME[a]
$\tau^{H,S}$	Fiscal Sub-secretariat/SPE/ME[a]
τ^{L}	Fiscal Sub-secretariat/SPE/ME[a]
τ^{K}	Fiscal Sub-secretariat/SPE/ME[a]

The procedure of Mendoza et al. (1994) was used to calculate the average effective tax rates on consumption, household contributions on wages, labor income tax, and capital income tax

The calibrated data for this study were obtained from various sources, including national accounts, academic literature, and financial institution reports. Long-term equilibrium values for output (Y_{ss}), consumption (C_{ss}), government spending (G_{ss}), government (I^{G}_{ss}) and private investment (I^{P}_{ss}), and financial expenditure consumption (CDF_{ss}) were all derived from national accounts. Specifically, C_{ss} was set at 65% of Y_{ss}, G_{ss} at 18% of Y_{ss}, I^{G}_{ss} at 2% of Y_{ss}, I^{P}_{ss} at 15% of Y_{ss}, and CDF_{ss} at 10% of Y_{ss}.

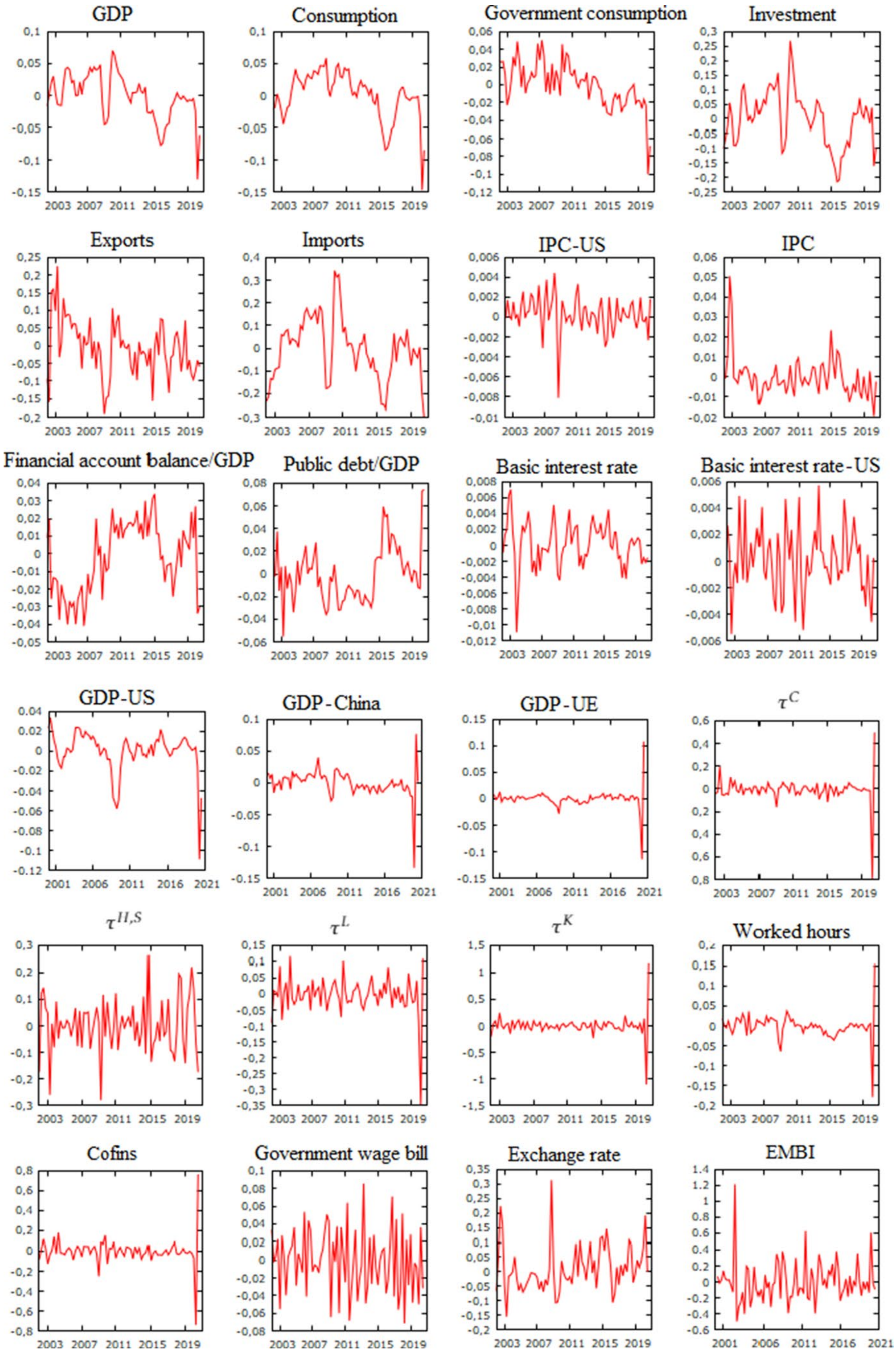

Fig. 18 Processed data used in Bayesian estimation. The series are in variations and detrended. Source: Authors' elaboration

The steady-state capital (K_{ss}) was calculated as 2,7 times the annual GDP (2,7*4 for quarterly GDP, Y_{ss}), as described by Morandi and Reis (2004). The production parameters α_1, α_2, and α_3 were obtained from Mussolini (2011), where α_1 was set at 0,3, α_2 at 0,6, and $\alpha 3$ at 0,1. The steady-state interest rate (R^B_{ss}) was based on the Selic rate, with a value of $1,02^{0,25}$, and the discount rate (β) was set as its inverse, $1/1,02^{0,25}$.

The capital depreciation rate (δ) was calculated as the ratio of total investment to total capital (I_{ss}/K_{ss}). The efficiency of government spending (Ξ_G) was calibrated at 1,2, according to Cavalcanti and Santos (2021). The tax rates on consumption (τ^C_{ss}), health and safety ($\tau^{HS}ss$), capital ($\tau^K ss$), and labor (τ^L_{ss}) were obtained using data from the Secretariat of Economic Policy (SPE) following Mendoza et al. (1994), with values of 0,21, 0,021, 0,19, and 0,3, respectively. Public debt (B^F_{ss}) was derived from the Balance of Payments (BP) data from the Central Bank of Brazil (BCB), with a value of 0,016. The parameter θ was based on Castro et al. (2015), set at 0,75. Parameters σ and φ_G were obtained from Galí (2008), both set at 1.

This calibration was performed to ensure that the model accurately reflects the characteristics and behaviors observed in the Brazilian economy, relying on credible sources and methodologies established in economic literature.

Table 7 reports the calibrated parameter values.

Table 7 Parameter Calibration

Parameter	Value	Source
Y_{ss}	1,923	National accounts
C_{ss}	0,65 Y_{ss}	National accounts
G_{ss}	0,18 Y_{ss}	National accounts
I^G_{ss}	0,02 Y_{ss}	National accounts
I^P_{ss}	0,15 Y_{ss}	National accounts
CDF_{ss}	0,1 Y_{ss}	National accounts
K_{ss}	$2{,}7 \times 4\, Y_{ss}$	Morandi and Reis (2004)
α_1	0,3	Mussolini (2011)
α_2	0,6	Mussolini (2011)
α_3	0,1	Mussolini (2011)
R^B_{ss}	$1{,}02^{0,25}$	Selic rate
β	$1/1{,}02^{0,25}$	1/selic
δ	I_{ss}/K_{ss}	–
Ξ_G	1,2	Cavalcanti and Santos (2021)
τ^C_{ss}	0,21	SPE
τ^{HS}_{ss}	0,021	SPE
τ^K_{ss}	0,19	SPE
τ^L_{ss}	0,3	SPE
B^F_{ss}	0,016	BCB/BP
θ	0,75	Castro *et al.* (2015)
σ	1	Galí (2008)
φ_G	1	Galí (2008)
φ_P	$\Xi_G\, \varphi_G$	–

Source: Author's elaboration

Estimation

Given the *prior* distribution of the parameters, the *posterior* distribution was estimated using a Markov chain process through the Metropolis-Hastings algorithm with 100,000 iterations, a scale factor of 0,1, and 2 parallel chains. Table 8 presents the *prior* and *posterior* distributions of each estimated parameter.

Table 8 Results from Metropolis-Hastings (parameters)

	Prior			Posterior			
	Dist.	Mean	Stdev.	Mean	Stdev.	HPD inf	HPD sup
χ_{BF}	unif	3.000	1.1547	3.230	0.0223	3.1939	3.2622
θ^W	unif	0.850	0.0289	0.855	0.0008	0.8538	0.8563
ψ_f	unif	1.105	0.0548	1.093	0.0017	1.0905	1.0955
γ^C	unif	0.800	0.0289	0.802	0.0006	0.8011	0.8031
χ	unif	3.000	1.1547	2.843	0.0240	2.8035	2.8812
P_{ss}^{INSF}	unif	1.050	0.5485	0.962	0.0154	0.9408	0.9846
P_{ss}^{CD}	unif	1.100	0.0577	1.121	0.0019	1.1186	1.1238
P_{ss}^{CF}	unif	1.050	0.5485	0.782	0.0116	0.7632	0.8016
γ_R	unif	0.800	0.0577	0.824	0.0031	0.8203	0.8278
γ_π	unif	2.500	0.2887	2.456	0.0064	2.4460	2.4638
γ_Y	unif	0.115	0.0202	0.123	0.0006	0.1219	0.1238
ω_R	unif	0.650	0.0866	0.674	0.0034	0.6697	0.6784
γ_G	unif	0.130	0.0693	0.115	0.0020	0.1123	0.1183
α_G	unif	0.200	0.0289	0.201	0.0009	0.2002	0.2027
τ_{ss}^{FS}	gamm	0.080	0.0040	0.078	0.0001	0.0782	0.0786
τ_{ss}^{imp}	gamm	0.250	0.0300	0.258	0.0009	0.2561	0.2589
γ_{WG}	beta	0.500	0.2500	0.515	0.0084	0.5031	0.5268
γ_{τ^C}	beta	0.500	0.2500	0.457	0.0028	0.4529	0.4618
ϕ_{τ^C}	unif	0.750	0.1443	0.732	0.0023	0.7277	0.7355
$\gamma_{\tau^{imp}}$	beta	0.500	0.2500	0.513	0.0115	0.4986	0.5286
$\phi_{\tau^{imp}}$	unif	0.500	0.2887	0.579	0.0066	0.5669	0.5891
γ_{τ^L}	beta	0.500	0.2500	0.474	0.0100	0.4602	0.4881
ϕ_{τ^L}	unif	0.750	0.1443	0.773	0.0024	0.7693	0.7765
$\gamma_{\tau^{HS}}$	beta	0.500	0.2500	0.569	0.0068	0.5583	0.5785
$\phi_{\tau^{HS}}$	unif	0.500	0.2887	0.560	0.0057	0.5518	0.5710
$\gamma_{\tau^{FS}}$	beta	0.500	0.2500	0.624	0.0087	0.6125	0.6350
$\phi_{\tau^{FS}S}$	unif	0.500	0.2887	0.509	0.0067	0.4993	0.5203
γ_{τ^K}	unif	0.725	0.0144	0.719	0.0003	0.7190	0.7198
ϕ_{τ^K}	unif	0.325	0.0144	0.332	0.0009	0.3309	0.3331
γ_T	beta	0.500	0.2500	0.587	0.0039	0.5803	0.5931

Table 8 (continued)

	Prior			Posterior			
	Dist.	Mean	Stdev.	Mean	Stdev.	HPD inf	HPD sup
ϕ_T	unif	0.750	0.1443	0.720	0.0082	0.7088	0.7295
γ_{IG}	beta	0.500	0.2500	0.507	0.0041	0.5015	0.5142
ϕ_{IG}	unif	-0.500	0.2887	-0.446	0.0080	-0.4569	-0.4329
γ_G	beta	0.500	0.2500	0.502	0.0038	0.4954	0.5076
ϕ_G	unif	-0.500	0.2887	-0.450	0.0039	-0.4561	-0.4433
$\rho_{S_T{}^C}$	beta	0.500	0.2500	0.527	0.0070	0.5174	0.5368
$\rho_{S_T{}^{imp}}$	beta	0.500	0.2500	0.315	0.0076	0.3002	0.3241
$\rho_{S_T{}^L}$	beta	0.500	0.2500	0.442	0.0097	0.4308	0.4591
$\rho_{S_T{}^{HS}}$	beta	0.500	0.2500	0.466	0.0146	0.4461	0.4838
$\rho_{S_T{}^{FS}}$	beta	0.500	0.2500	0.589	0.0043	0.5810	0.5951
$\rho_{S_T{}^K}$	beta	0.500	0.2500	0.541	0.0058	0.5307	0.5493
ρ_{ST}	beta	0.500	0.2500	0.441	0.0030	0.4355	0.4451
ρ_{SIG}	beta	0.500	0.2500	0.435	0.0068	0.4256	0.4440
ρ_{YF}	beta	0.500	0.2500	0.487	0.0020	0.4840	0.4905
ρ_{RF}	beta	0.500	0.2500	0.553	0.0040	0.5479	0.5601
ρ_{PCF}	beta	0.500	0.2500	0.703	0.0036	0.6984	0.7101
ρ_{PINSF}	beta	0.500	0.2500	0.493	0.0100	0.4787	0.5057
ρ_A	beta	0.500	0.2500	0.450	0.0101	0.4352	0.4631
ρ_L	beta	0.500	0.2500	0.419	0.0051	0.4107	0.4268
ρ_P	beta	0.500	0.2500	0.536	0.0066	0.5280	0.5454
ρ_{SG}	beta	0.500	0.2500	0.585	0.0047	0.5775	0.5914
ρ_{Sm}	beta	0.500	0.2500	0.393	0.0038	0.3864	0.3987
ρ_{SI}	beta	0.500	0.2500	0.569	0.0037	0.5633	0.5756
ρ_{markup}	beta	0.500	0.2500	0.471	0.0052	0.4632	0.4796
$\rho_{markupW}$	beta	0.500	0.2500	0.634	0.0050	0.6265	0.6428
θ_1	beta	0.500	0.2500	0.466	0.0076	0.4542	0.4768
θ_2	beta	0.500	0.2500	0.594	0.0036	0.5885	0.6002
θ_3	beta	0.500	0.2500	0.413	0.0045	0.4073	0.4219
θ_4	beta	0.500	0.2500	0.543	0.0061	0.5350	0.5531
θ_5	beta	0.500	0.2500	0.476	0.0087	0.4645	0.4892
θ_6	beta	0.500	0.2500	0.555	0.0165	0.5337	0.5761
θ_7	beta	0.500	0.2500	0.571	0.0020	0.5675	0.5738
θ_8	beta	0.500	0.2500	0.543	0.0037	0.5380	0.5494
θ_9	beta	0.500	0.2500	0.466	0.0071	0.4553	0.4771
θ_{10}	beta	0.500	0.2500	0.472	0.0107	0.4552	0.4863
θ_{11}	beta	0.500	0.2500	0.562	0.0070	0.5507	0.5715
θ_{12}	beta	0.500	0.2500	0.495	0.0123	0.4803	0.5111
θ_{13}	beta	0.500	0.2500	0.484	0.0033	0.4791	0.4899
θ_{14}	beta	0.500	0.2500	0.518	0.0076	0.5078	0.5300
θ_{15}	beta	0.500	0.2500	0.558	0.0028	0.5528	0.5623

Table 8 (continued)

	Prior			Posterior			
	Dist.	Mean	Stdev.	Mean	Stdev.	HPD inf	HPD sup
ε_A	invg	1.000	Inf	0.129	0.0076	0.1176	0.1396
ε_P	invg	1.000	Inf	0.717	0.0919	0.5976	0.8747
ε_L	invg	1.000	Inf	0.279	0.0475	0.2023	0.3555
ε_{SG}	invg	1.000	Inf	0.130	0.0086	0.1176	0.1412
ε_{Sm}	invg	1.000	Inf	0.939	0.0174	0.9067	0.9627
ε_{StauC}	invg	1.000	Inf	0.152	0.0135	0.1317	0.1748
$\varepsilon_{Stauimp}$	invg	1.000	Inf	0.207	0.0225	0.1708	0.2438
ε_{StauL}	invg	1.000	Inf	0.147	0.0140	0.1234	0.1697
ε_{StauHS}	invg	1.000	Inf	0.148	0.0159	0.1211	0.1724
ε_{StauFS}	invg	1.000	Inf	1.538	0.0442	1.4751	1.6144
ε_{StauK}	invg	1.000	Inf	0.214	0.0240	0.1743	0.2524
ε_{SIG}	invg	1.000	Inf	1.403	0.0625	1.3166	1.5161
ε_{YF}	invg	1.000	Inf	0.123	0.0048	0.1176	0.1287
ε_{RF}	invg	1.000	Inf	0.121	0.0035	0.1176	0.1258
ε_{PCF}	invg	1.000	Inf	1.189	0.0630	1.1121	1.2721
ε_{PINSF}	invg	1.000	Inf	1.051	0.0685	0.9321	1.1440
ε_{ST}	invg	1.000	Inf	0.321	0.0551	0.2426	0.4190
ε_{SI}	invg	1.000	Inf	0.151	0.0161	0.1239	0.1754
ε_{markup}	invg	1.000	Inf	0.646	0.0187	0.6196	0.6726
$\varepsilon_{markupW}$	invg	1.000	Inf	0.127	0.0069	0.1176	0.1365
ε_1	invg	1.000	Inf	0.727	0.0364	0.6775	0.7888
ε_2	invg	1.000	Inf	0.121	0.0034	0.1176	0.1261
ε_3	invg	1.000	Inf	0.141	0.0122	0.1208	0.1591
ε_4	invg	1.000	Inf	0.141	0.0134	0.1177	0.1587
ε_5	invg	1.000	Inf	1.475	0.0367	1.4272	1.5247
ε_6	invg	1.000	Inf	0.180	0.0245	0.1388	0.2172
ε_7	invg	1.000	Inf	0.125	0.0060	0.1176	0.1334
ε_8	invg	1.000	Inf	0.365	0.0397	0.2977	0.4206
ε_9	invg	1.000	Inf	0.152	0.0161	0.1257	0.1781
ε_{10}	invg	1.000	Inf	0.138	0.0126	0.1176	0.1567
ε_{11}	invg	1.000	Inf	0.218	0.0303	0.1678	0.2692
ε_{12}	invg	1.000	Inf	0.225	0.0316	0.1730	0.2740
ε_{13}	invg	1.000	Inf	0.795	0.0401	0.7292	0.8503
ε_{14}	invg	1.000	Inf	0.199	0.0248	0.1596	0.2382
ε_{15}	invg	1.000	Inf	0.136	0.0131	0.1176	0.1549

6.2 Model Reliability Test (Continued)

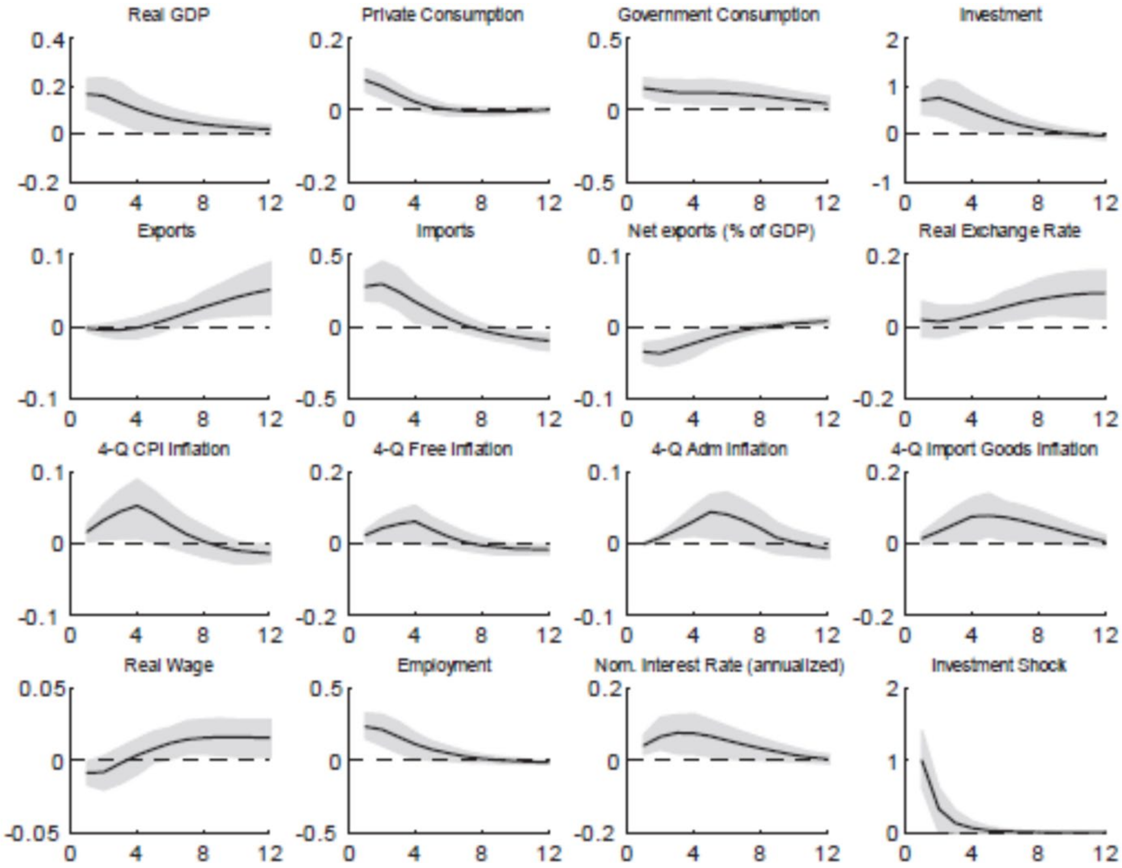

Fig. 19 IRF of productivity shock in investment in SAMBA. Source: Authors' elaboration

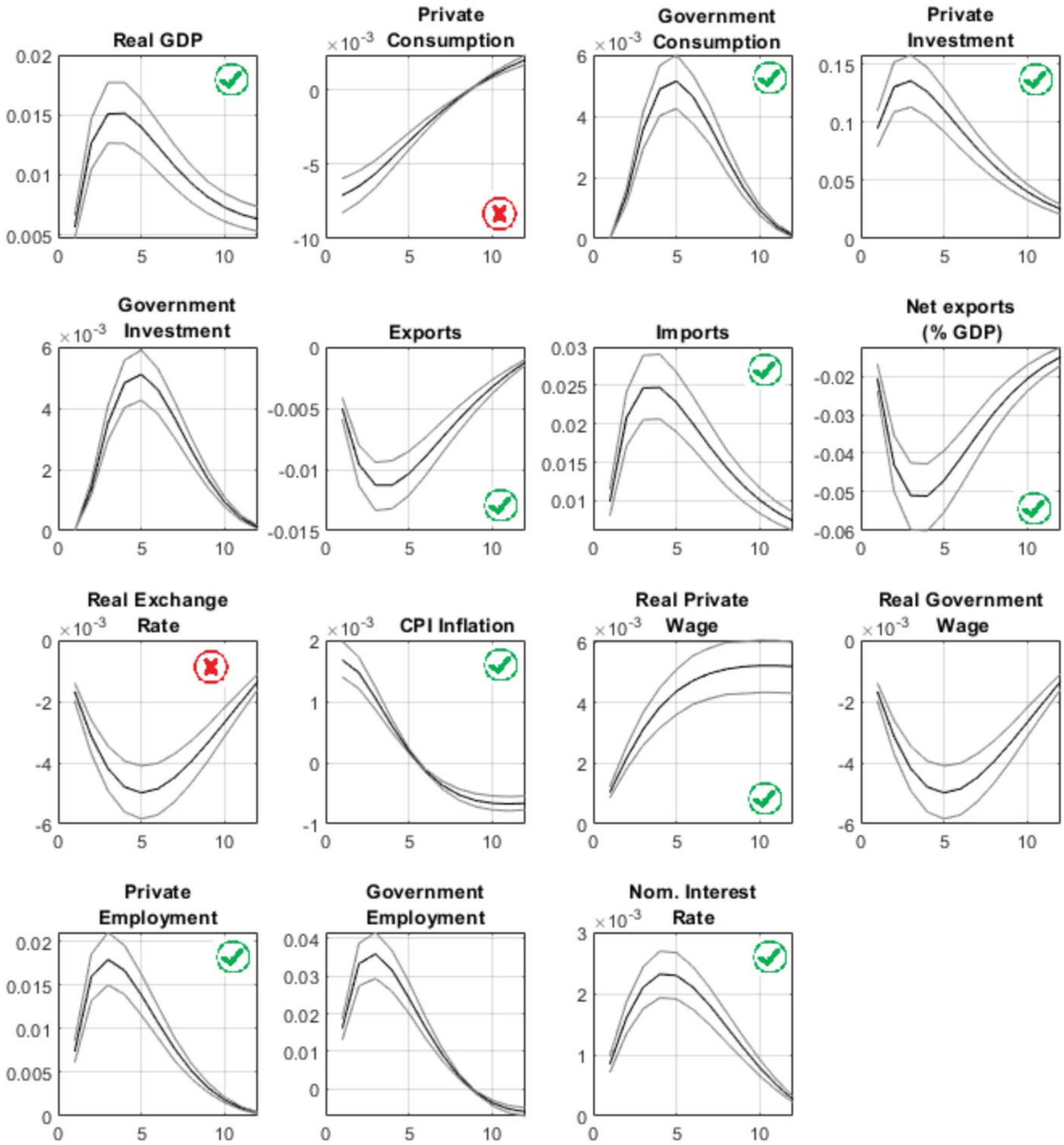

Fig. 20 IRF of productivity shock in investment in the SNA-compliant DSGE model. Source: Authors' elaboration

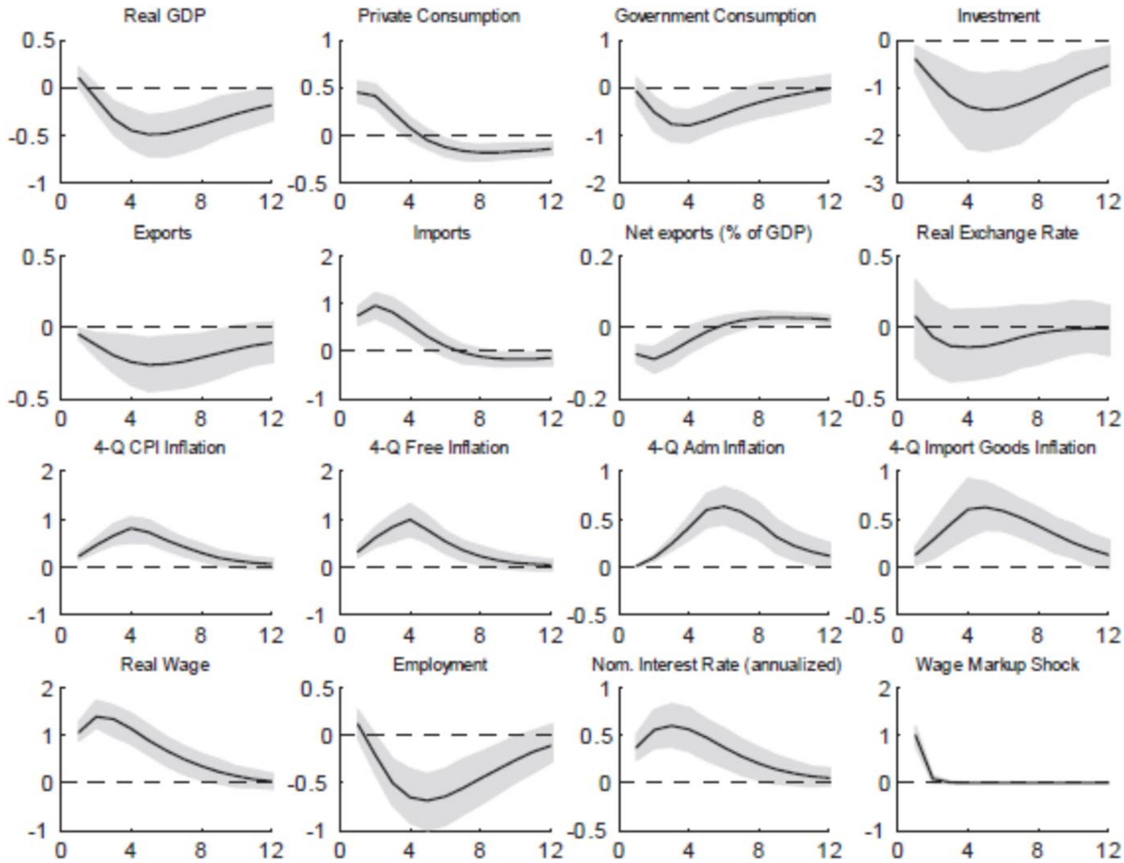

Fig. 21 IRF of wage markup shock in SAMBA. Source: Authors' elaboration

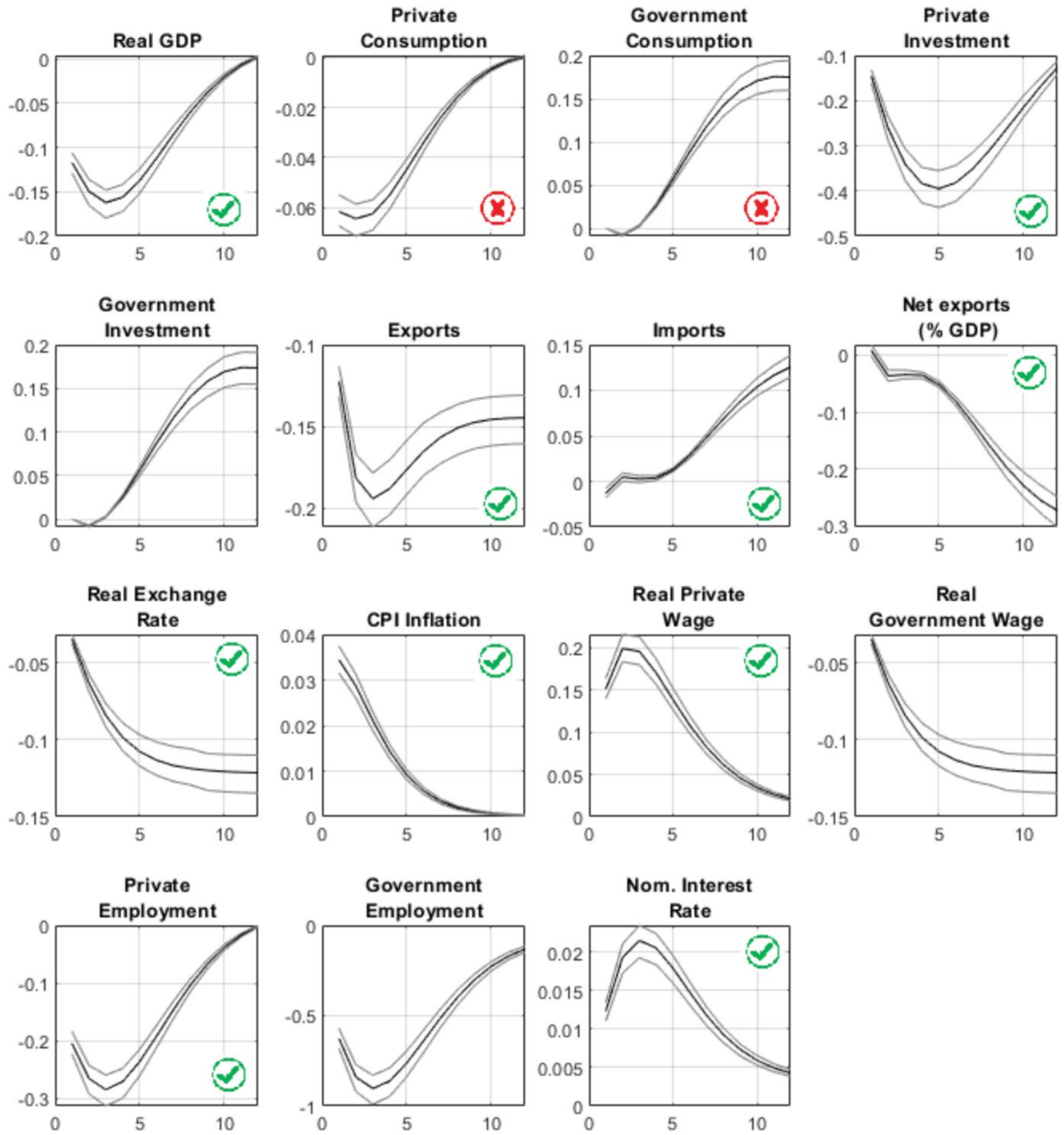

Fig. 22 IRF of wage markup shock in the SNA-compliant DSGE model. Source: Authors' elaboration

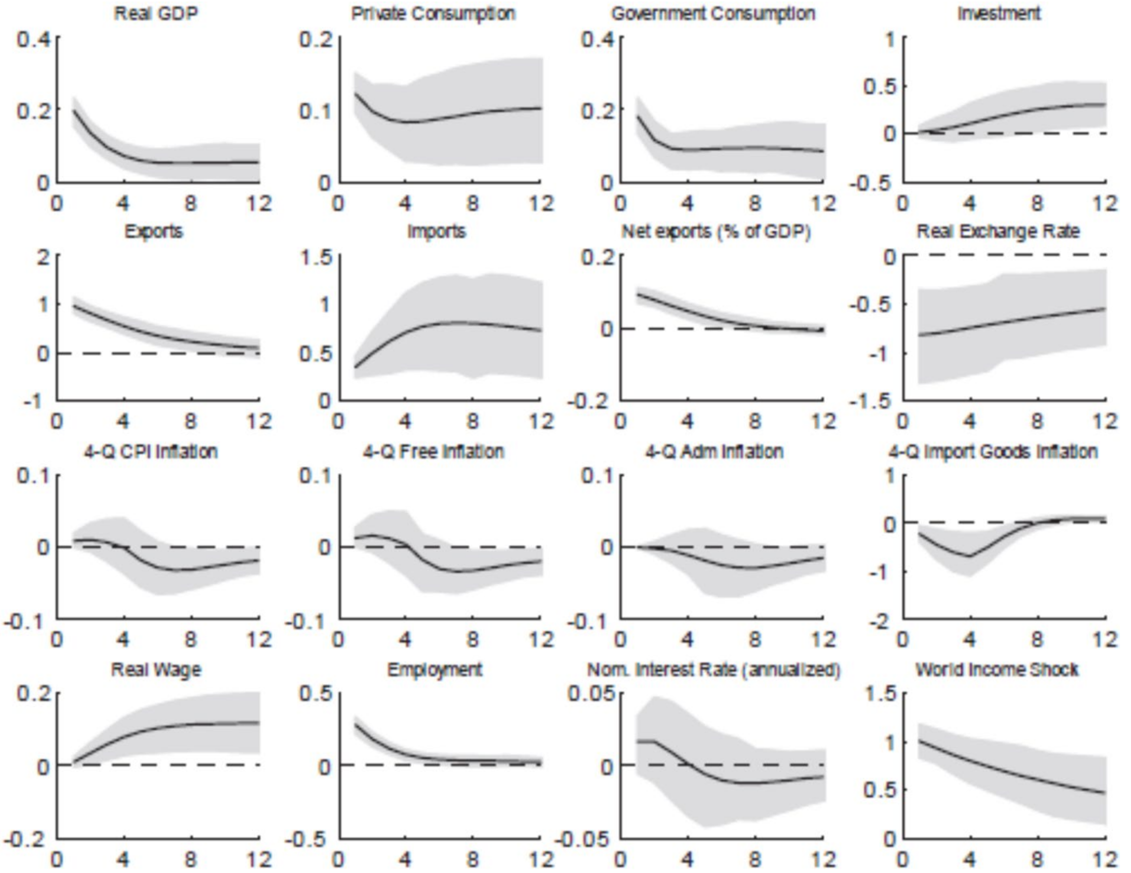

Fig. 23 IRF of foreign income shock in SAMBA. Source: Authors' elaboration

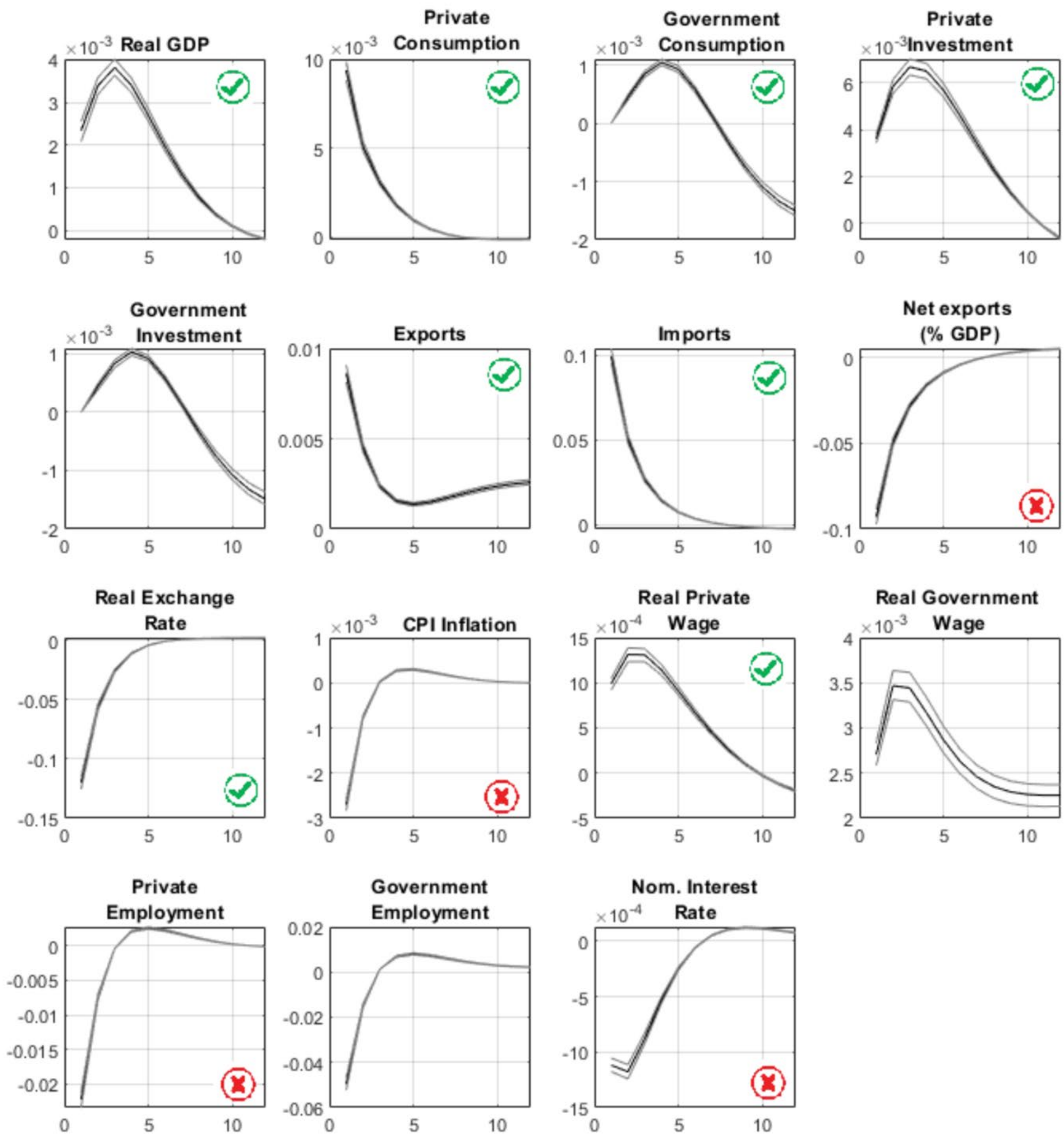

Fig. 24 IRF of foreign income shock in the SNA-compliant DSGE model. Source: Authors' elaboration

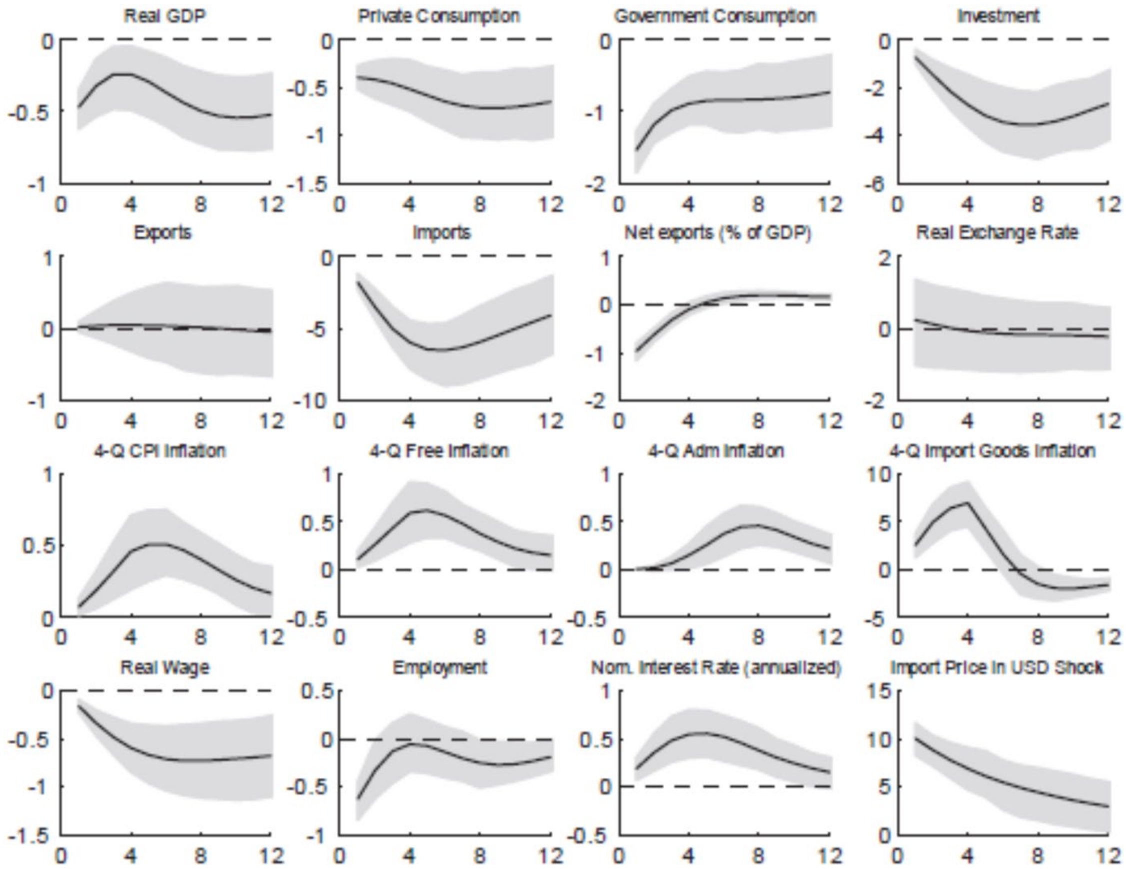

Fig. 25 IRF of imported input price shock in SAMBA. Source: Authors' elaboration

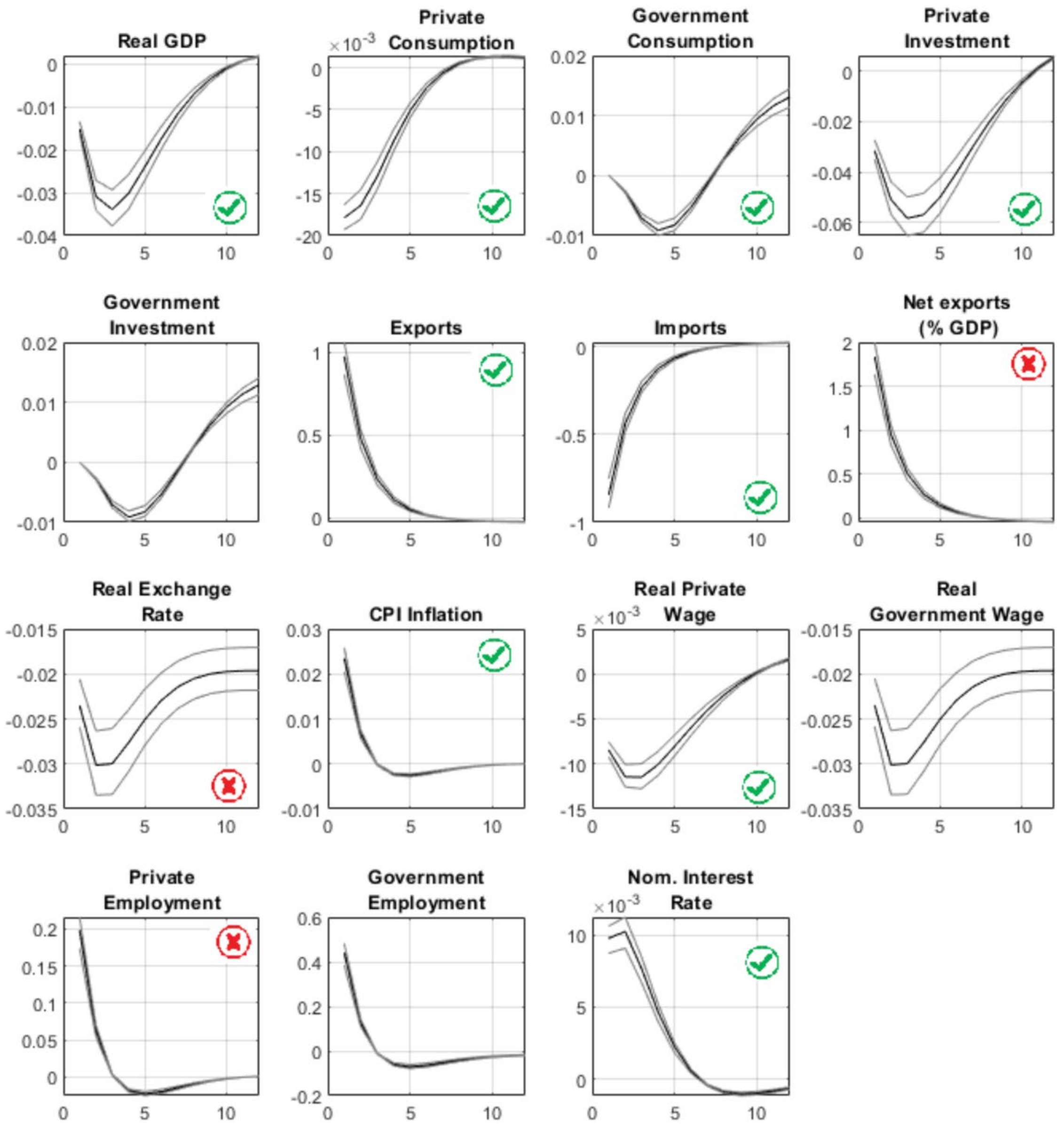

Fig. 26 IRF of imported input price shock in the SNA-compliant DSGE model. Source: Authors' elaboration

Appendix B: Comparison Cetween Baseline vs. CES Specification

Headline Moments (Levels And % Change)

Metric (std. dev.)	Baseline	CES	Δ% (CES vs. Base)
Y	5.47	4.92	−10.0%
C	2.59	2.43	−6.3%
G	7.32	6.86	−6.3%
$Serv^G$	17.81	16.29	−8.5%
By	20.10	18.76	−6.7%
Taxes	9.99	9.07	−9.2%

With CES the economy becomes *slightly less volatile* across the board—output, consumption, government services, debt ratio, and tax revenues all fluctuate somewhat less.

Persistence and Co-Movement

- Autocorrelation $\rho(1)$:
  - Y: baseline $\approx 0.919 \ \rightarrow \ 0.903$ (CES) $\Rightarrow$ slightly less persistent.
  - C: baseline $\approx 0.873 \ \rightarrow \ 0.849$ (CES) $\Rightarrow$ slightly less persistent.
- Correlation $\mathrm{corr}(Y, C)$: baseline $\approx 0.960 \ \rightarrow \ 0.951$ (CES). Still strongly procyclical, but marginally lower.

Variance Decomposition of *Y*

Shock	Baseline (%)	CES (%)
Price markup (e^{markup})	28.8	28.8
Wage markup ($e^{markupW}$)	44.0	43.0
Investment efficiency (e^{SI})	11.5	10.7
Public wage (e^{WG})	1.9	3.1

Output volatility remains dominated by markup shocks (goods + wages $\approx 72\%$ in CES). CES slightly raises the role of public-wage shocks and slightly lowers the role of investment efficiency.

Variance Decomposition of Private Investment *IP*

Shock	Baseline (%)	CES (%)
Investment efficiency (e^{SI})	35.8	42.4
Price markup (e^{markup})	17.1	14.8
Wage markup ($e^{markupW}$)	38.1	35.0

Under CES, private investment becomes more sensitive to investment-efficiency shocks and slightly less to markup shocks.

Summary

- CES dampens volatility (6–10% reductions across key aggregates).
- Slightly less persistence in Y and C.
- Y still driven mainly by markup shocks.
- Private investment shifts more toward investment-efficiency shocks under CES.Overall, these results show that adopting a CES aggregator leaves our main conclusions unaltered. The CES specification dampens volatility and slightly al-

ters the transmission of certain shocks, but the broad cyclical behavior and policy implications remain essentially unchanged. We therefore regard the linear specification used in the baseline model as both transparent and empirically adequate, while the CES robustness exercise confirms that our findings are not an artifact of functional-form assumptions.

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Declarations

Competing interest The authors declare no competing interests.

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